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FINAL REPORT INSTALLATION RESTORATION PROGRAM

PHASE II — CONFIRMATION McCLELLAN AFB, CALIFORNIA

VOLUME I

PREPARED FOR

US AIR FORCE OCCUPATIONAL AND ENVIRONMENTAL HEALTH LABORATORY BROOKS AFB, TEXAS

JUNE 1983

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Letter on flo

FINAL REPORT

INSTALLATION RESTORATION PROGRAM PHASE II - CONFIRMATION McCLELLAN AFB, CALIFORNIA

VOLUME I

Prepared for

US AIR FORCE
OCCUPATIONAL AND ENVIRONMENTAL HEALTH LABORATORY
BROOKS AFB, TEXAS

June 1983

Prepared by

Engineering-Science
125 West Huntington Drive

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22 June 1983

ES File 9793

Mr. Emile Baladi USAF OFHL/EC Brooks AFB, Texas 78235

Subject: Final Report, Contract F33615-80-D-4001,

Call Order Number 20

Dear Mr. Baladi:

Enclosed is the Engineering-Science, Inc. (ES) Final Report entitled "Installation Restoration Program, Phase II - Confirmation, McClellan AFB, California". The large amount of information and data generated during the project necessitated division of the report into two volumes. The first volume contains the report narration and the first few appendices; the second volume contains the remaining report appendices.

The report narration presents introductory background information on the Installation Restoration Program, a description of the environmental setting at McClellan AFB, an explanation of the field program, a discussion of field and analytical results, and an examination of possible alternative measures.

Engineering-Science has been pleased to be able to provide services to the Air Force. Please do not hesitate to contact us with any questions.

Sincerely,

James L. Mang

Project Manager

Gordon S. Magnuson Division Vice President

JLM/GSM/elj

Enclosures

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EXECUTIVE SUMMARY

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EXECUTIVE SUMMARY

INTRODUCTION

The United States Air Force, due to its primary mission to militarily defend the United States through the operation and maintenance of aircraft, has long been engaged in a wide variety of operations that require handling toxic and hazardous materials. Federal, state, and local governments have developed strict regulations that require disposers of these materials to identify the locations and contents of waste disposal sites and to implement action to eliminate any hazards to the public health or the environment. The Department of Defense (DOD) has issued Defense Environmental Quality Program Policy Memorandum 81-5 which requires the identification and evaluation of past hazardous material disposal sites on DOD property, the control of migration of hazardous contaminants, and the control of hazards to the public health and welfare that resulted from these past operations. This program is called the Installation Restoration Program (IRP). The IRP serves as a basis for response actions on Air Force installations under the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980.

The Installation Restoration Program has been developed as a fourphased program. These phases are:

- Phase I Installation Assessment
- * Phase II Confirmation
- * Phase III Technology Base Development
- * Phase IV Operations

Phase I, completed at McClellan Air Force Base in July 1981, includes the identification and prioritization of past disposal sites that could pose a hazard to public health or the environment as a result of contaminant migration. Thase II consists of a comprehensive preliminary

environmental survey to define and quantify the presence or absence of contamination that may adversely affect public health or the environment. During Phase III, a data base will be developed upon which to prepare a comprehensive contaminant control plan. This contaminant control plan will be implemented in Phase IV.

This report describes the work performed during the Phase II program at McClellan AFB, California, including development of recommendations for follow-on actions and future monitoring.

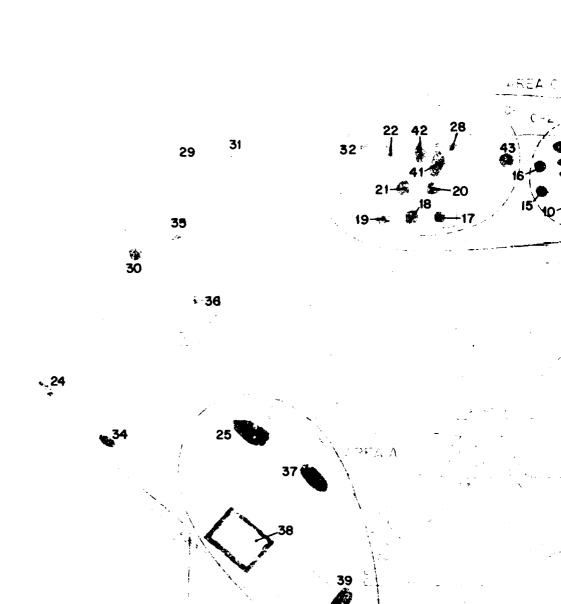
The Phase I study was a records search assessing the potential for groundwater quality problems on McClellan AFB (CH2M Hill, 1981). The Phase I report included information generated by the Air Force in a study entitled "Investigating Ground Water Contamination as of 30 April 1981" (Brunner and Zipfel, 1981). The records search program resulted in the identification of two main areas of concern. These were (1) organic solvents found to be present in groundwater and (2) polychlorinated biphenyls (PCB's) contained in soil in a small area located at the northwest corner of the runway clear zone as a result of previous land owner activities. The soils containing PCB's were removed by the Air Force and transported to an approved PCB site. The Phase I report recommended the implementation of an expanded monitoring program in Phase II to determine the extent of organic constituents in groundwater. The results of that program are discussed in this report.

Forty-six active and inactive waste disposal and storage sites were identified in the Phase I report. Using the Air Force's Hazard Assessment Rating Methodology (HARM System), the sites were evaluated on the basis of site characteristics, potential for contamination, waste characteristics, and waste management practices. Most of the sites were envisioned as forming four discrete site clusters across the Base. The estimated locations of these sites and site clusters are illustrated on Figure B.1. In some instances the exact site location is unknown.

FIELD PROGRAM

Prior to the development of the field program an extensive review of existing information on geologic conditions and aquifer systems was conducted. Based on that information and specific recommendations from

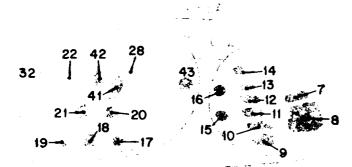
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LEGEND

Disposal/Storage Areas

NOTE: Description of each Site is found in Table 2.1

LOCATION OF DISPOSAL AND STORAGE SITES McCLELLAN AFB, CA

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the Phase I report, a field program was developed that included installing monitoring wells, analyzing groundwater samples, conducting aquifer tests, investigating an industrial waste line, and locating an abandoned Base water supply well.

The drilling program at McClellan AFB was implemented in two successive stages. A total of 48 monitoring wells were installed during this two-phased program. The location and depth of Stage I monitoring wells were determined on the basis of existing hydrogeological information for the Base (primarily well logs from previously installed monitoring and water supply wells) and location of past disposal and storage areas on the Base. The Stage II drilling program was designed on the basis of analytical results obtained for the Stage I groundwater samples. Pump and slug tests were conducted to evaluate the transmissibility of water-bearing sands and lateral and vertical continuity between each sands zone. One pump test and three slug tests were performed. Seven wells were tested for specific conductance and temperature in the field. Readings were taken in wells to determine whether stratification was evident within a well and whether detectable differences could be noted between the shallow and deeper aquifers.

Part of the Stage I field program included establishing the location of Base production well 7. This was necessary since it was thought that well 7 could be a conduit for water to travel from near the surface down to lower production aquifers. Abandonment of the well in past years left no clue on the surface as to its location. A search of Base utility records showed the approximate location to be near the west side of Building 475 in an underground well house. The buried well building was located with a magnetic flux indicator (Schonstedt GA-52 Magnetic Locator), and the site was excavated for evaluation of the well head. The well head, located in the building basement, was found to be encased with concrete and fitted with a non-watertight fabricated steel cap; the gravel pack was sealed by a 24-inch outer casing. A watertight cap was installed on the 24-inch casing, in addition to a supplemental lockable steel cap. The well was found to be obstructed at an 80-foot depth, even after attempted clean-out of the well by rotary-wash drilling. Evidence from Base personnel interviews indicates the well casing probably was grouted in the late 1960's or early 1970's. Because a substantial amount of excess water from fill material drained into the well during excavation, sampling of BW7 for priority pollutants was not accomplished.

An investigation of the industrial waste collection system in the vicinity of Building 251 was performed in January 1982. The purpose of this investigation was to determine if the industrial waste line was a possible source of constituents that necessitated closure of two Base production wells in the immediate vicinity. The investigation included three soil borings beneath the line.

FINDINGS

Results of the field program demonstrated that the Base is underlain by a shallow sands zone at depths ranging from approximately 80 to 100 feet below ground surface. This zone varies in thickness from 1 foot to 17 feet and may be discontinuous in places. Permeabilities range from 0.8 to 4.2 gpd per square foot, and transmissibilities range from 4.7 to 21 gpd per foot. The groundwater in this zone moves in a south-southwesterly direction and is influenced locally primarily by off-base production wells. Based on physical characteristics, it appears that groundwater in this zone would move off Base no more than 1,000 feet in 40 years. However, localized pumping may accelerate this rate. Deeper aquifers exist, disconnected from the shallow sands and separated by at least 20 feet of predominately fine-grained material.

Since off-base wells may have been constructed with gravel packs and perforations in the shallow sands zone, constituents in groundwater (that could be the result of past McClellan AFB waste disposal practices) could migrate downward into lower aquifers causing water quality problems with off-base water supply wells. Sufficient time has passed since the disposal of waste material on McClellan property for constituents in the first sands beneath the Base to cause problems in public and private water supply wells.

Groundwater samples from all wells on the Base were analyzed for selected organic and inorganic constituents. The shallow aquifer (first sands zone) shows the presence of constituents particularly along the

western border of the Base where former disposal sites existed. However, the data also show organic compounds and trace metals in shallow wells throughout the Base; often, these wells were not located near a known disposal area. The occurrence of these constituents in wells with no apparent known source indicates that the delineation of plumes from individual site locations may not be possible.

Numerous factors contribute to the fact that identification of constituent plumes in groundwater from individual sites on Base may be impossible. These factors include potentially unknown sites and varying groundwater table elevations, as well as the operation of disposal sites at different times. In addition, in many cases groundwater has flowed beneath several sites, picking up constituents from one or more areas. It is possible that chemical constituents may be identified in downgradient areas off the Base. The interface between areas containing detectable constituents and those areas which do not could be considered the leading edge of a plume. Phase II of the IRP did not provide for any off-base activity, so plume movement outside the boundaries of the Base was only estimated.

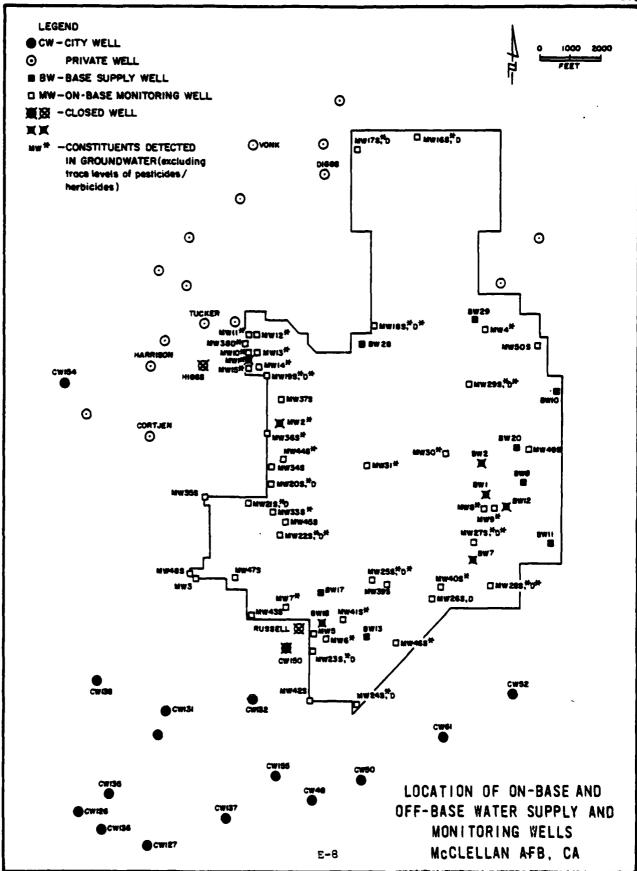
The deeper aquifer (second sands zone) shows constituents near or below limits of detection, except pesticides and herbicides. A deep well located downgradient of the sludge pit area in the northwest corner of the Base clearly shows an absence of constituents, even though it is situated in an area exhibiting "worst case" conditions.

Selected analyses of wells showed negative results in most cases. PCB analyses of all monitoring wells installed on the Base during Stages I and II resulted in non-detectable concentrations. However, aroclor (a polychlorinated biphenyl) was present above detection limits in one Base production well in a single sampling event. Low concentrations of cyanide were detected in six monitoring wells on the Base, including one well installed at the upgradient Base boundary. A seventh well contained an elevated cyanide concentration. Cresylic acid was detected in a shallow well placed between the suspected source (Building 475) and Base production well 7 (abandoned). Two wells (shallow and deep) placed downgradient from production well 7 did not contain cresylic acid. Aliphatic material (grease and oil) appeared at elevated concentrations in

one well along the western edge of the Base. This material has not reached the second aquifer but has migrated in a southerly direction.

The presence of herbicides and pesticides in all of the shallow wells and most of the deeper wells is universal across the Base. centrations vary from one well location to another, and from one sampling to the next within the same well. The actual appearance of a particular compound is not consistent. One sampling often shows a compound that is not detected during a subsequent sampling. The source of these herbicides and pesticides in the groundwater may be partially from Base application and/or disposal. Bowever, monitoring wells placed upgradient at the extreme north end of the Base show the presence of herbicides and pesticides in the shallow and deep aquifers. of groundwater for both wells is off Base from the north. and pesticides are therefore being contributed to on-base groundwater from off-base sources. Historical records do show that two off-base production wells north of the Base contain 2,4,5-TP (Silvex). occurrence of these herbicides and pesticides appears to be ubiquitous.

Figure E.2 depicts the location of all monitoring wells on the Base, and denotes those wells where measurable concentrations of most constituents were identified. A general range of constituent concentrations found in all on-base shallow wells is compiled in Table E.1. These data reflect results only for constituents identified at measurable levels in at least one well. Analytical reports which present comprehensive results for all constituent analyses performed are contained in the appendices. Constituent values lower than the detection limits were not used to calculate the range of concentration except for those constituents found at detectable levels in only one or two shallow groundwater samples. For these constituents, it was not possible to tabulate low and/or median concentrations representing measurable In these instances, trace level data and "not detected" results were used to establish the range of concentration. The source areas in which the high concentrations were found are noted in the table. Table E.2 provides a range of the most common volatile organic constituent concentrations from different source areas.



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TABLE E. 1

NAMES OF CONSTITUENT CONCENTRATIONS DETECTED IN BASE MONITORING MELLS AND STAGE I AND II SHALLOW WELLS

	•	Minimum				
Const Stunne	UNIT OF	Detection			Concentration	
		19491	Spurce Area	High	PO-	Median
Volatiles						
Denzene	90	4.01	•	90	;	•
carbon tetrachloride	- 4 64	4	•	946	2	;
chloreform	400			67		95
1, 1-dichloroethane		::	.	126	'n	70
1, 2-dichloroethene	2 2	: :	3 (250	6	=
1.1-dichlorosthylese	4	: :	3 (2.1	9	윺
1.2-transdichlorosthulene		2 ;	s :	63,000	'n	2,500
	2	.	۵	200	•	2
	qdd	9.	1 -0	220	ą	95
methylene chloride	ą.	<u>-</u>	۹.	5,000	1,000	3.000
tetrachloroethylene	qdd	- ·	٩	70	un	=
toluene	ą.	٠.	1- 5	770		2 9
1, 1, 1-trichloroethane	qdd	-	•	12,000		
trichlorosthylene	qdd	9.	•	14: 100	3	
trichlorofluoromethane	qdd	9.1	. 5		,	5 9
vinyl chloride	98	•		- (2 ;	
•	Ļ	:	•	9	20	25
Acid Compounds						
2,4-dimethylphenol	qoo	9,1	c	3	ţ	;
pentechlorophenol	400		. 8		2,	<u>e</u>
phenol	4	•		907	•	2
		2	a	90	9	95
Base/Meutral Compounds						
anthracene	4	•	•	•		
blata-ethylkeryllythere	2 4 2 1	· ·	C-1	220	2	01. 01.
1.2-dichlorobenzene	2 1		ပေး	230	•	20
	2		9	00	23	32
	add.	٠ <u>.</u>	٥	50	~10	•
	2	·.	٥	•	2	12
dispersion parentes	946	•. •	7.	ø	9	900
i i dorana	g.	.	C-1	06	<u>Q</u>	9
	qdd	-	1-0	2	610	25
7, Z, 4-trichlorobensene	ą.	-	٥	12	-	•
Pesticides/Nerbicides						
Aldrin	qdd	0.003	٥	6.97	6.041	6
alpha-BRC	qdd	0.007	•			
beta-BHC	. 4	0.004	. [6.032
delta-BBC	466	700		70.0	0.00	0.048
game-BHC (lindane)	1	7 60 6	Ţ. <u>!</u>	5	0.025	9.066
2.4-D	£ 1	700.0		2.76	0.002	0.038
2.4.54		9.00	C-2	0.56	0.003	0.063
2.4 A.400 (851)	2	9.00	- C-1	0.001	0.002	0.002
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	q.	900.0	۵	0.20	<0.00	900 · 0>

TABLE E.1 (Continued)

	;	Minimum				
Constituent	Unit of Measurement	Detection	Source Area	Mah	Concentration	Madian
endosulfor sulfate	qdd	0.03	ပ	0.011	<0.03	<0.03
heptachlor	2	0.007	680	0.68	0.013	0.056
heptachlor epoxide	qdd	₽00.0	088	0.17	0.007	0.027
Metals						
ant imony	1/6	0.005	۵	90.0	900.0	0.008
arsenic	1/6	9.02	٥	99.0	0.24	0.30
cadalus	1/6=	0.01	VIO	0.08	0.0	0.014
chrostum	1/2=	0.02	٥	4.17	0.07	0.12
cobber	1/6	0.02	٥	1.18	0.12	0.33
lead	1/6=	0.01	<	96.0	0.01	0.633
Mercury	1/6=	0.0005	090	0.0027	0.0005	0.0012
nickel	1/6	0.02	UIA	2.13	9.02	0.08
solenium	1/6=	0.01	٥	0.355	0.01	0.049
RINC	1/64	0.03	088	11.4	0.03	0.07
Selected Analyses						
cresylic acid (Cresol)	1/6"	'n	<	26	\$	7
cyanide	1/6=	0.03	UIA	0.95	0.02	0.03

a List of constituents excludes those which were not detected in any shallow groundwater sample. A total of 77 constituents were tested and not found above detection limits. Comprehensive results for all analyses performed are contained in Appendices K, L, b Area in which high concentration was detected:

A - Area C - Area C

C-1 - Subarea C-1 C-2 - Subarea C-2

D - Area D

DBB - Downgradient Base Boundary

UBB - Upgradient Base Boundary UIA - Upgradient Base Industrial Area c ND - Not detected defended for only two shallow groundwater samples.

TABLE E.2

RANGE OF VOLATILE ORGANIC CONSTITUENT CONCENTRATIONS IN SHALLOW GROUNDWATER FROM DIFFERENT SOURCE AREAS

Source Area	Disposal Sites Upgradient From Affected Wells Containing Volatile Organics	Range of Concentrations of Most Common Volatile Constituents in Groundwater
AREA A	25, 37, 38, 34, 40	trichloroethylene: ND-50 ppb
AREA B	30,36	1,1-dichloroethylene: ND-5 ppb 1,2-trans-dichloroethylene: ND-10 ppb trichloroethylene: ND-118 ppb
SUBAREA C-1	41,42,43	ethylbenzene: ND-220 ppb toluene: ND-440 ppb trichloroethylene: ND-2,000 ppb
SUBAREA C-2	7,8,9,10,11,12, 13,14,15,16	1,1-dichloroethylene: ND-30 ppb tetrachloroethylene: ND-5 ppb trichloroethylene: ND-10 ppb
AREA D	1,2,3,4,5,6,26,27	1,1-dichloroethylene: 500-63,000 ppb 1,1,1-trichloroethane: ND-12,000 ppb trichloroethylene: 160-14,100 ppb

ND - not detected

Analytical results of groundwater samples from the deeper water-bearing materials indicate the deeper zone is "cleaner" than the shallow aquifer, with constituents mostly near or below limits of detection except for pesticides and herbicides. In general, the deeper sands appear to contain no EPA priority pollutants; the absence of constituents is consistent at most well locations.

All three soil borings beneath the industrial waste line contained trace metals, specifically arsenic and selenium, at both the 15-foot and 20-foot depths.

CONCLUSIONS

Past waste disposal practices at McClellan AFB have resulted in the creation of three types of problems. These are (1) affected materials (disposed waste and soils), (2) on-base water supply, and (3) off-base water supply. The groundwater affected by past disposal activities appears to be limited primarily to the shallow sands zone. That zone, which varies in thickness from 1 foot to 17 feet, is a very poor producer of water. Based on estimated groundwater velocities, constituents in the shallow sands have probably migrated outside Base boundaries up to a distance of 1,000 feet. However, this rate of movement may be accelerated by local pumping. Private and public water supply wells located off the Base are most likely gravel packed to depths exceeding 50 feet below the ground surface, with perforations possibly at greater depths. The deeper water-bearing sands are probably continuous off Base where they are tapped by private and public wells for water supply.

RECOMMENDATIONS

Recommended follow-on actions and future monitoring for each problem area are summarized in Table E.3.

TABLE E.3

RECOMMENDED ACTIONS AND MONITORING MCCLELLAN AFB, CALIFORNIA

Problem	Recommended Action and Monitoring	Rationale	Implementation Priority ^a
Affected Materials	• Ensure that Sites 8 and 40 are closed to seek MCRA requirements	* Prevent precipitation moisture from contacting affected materials/Met PCRA require- ments	N
	• Close Site 4 to meet RCRA requirements to include placing 4 feet of soil/cement mixture within the pit, and subsequently cap the site to prevent surface infiltration	* Absorb moisture on pit surface/ Prevent precipitation moisture from contacting affected meterials	-
	Inspect sites in Area A (25), Area B (10), Suberea C-1 (41, 42, 43), Suberea Suberea C-2 (7, 6, 9, 10, 11), and Area D (2, 3, 4, 5, 6, 26, 27) to evaluate status of surface conditions. Cover sites with impermeable cap designed to divert surface water from the site	* Prevent precipitation moisture from contacting affected mate- rials	• Area D: 2 • Subarea C-1: 3 • Area B: 3 • Subarea C-2: 4 • Area A: 4
On-Bese Water Supply	* Seal gravel pack on Base production wells 1, 8, 13, 18, 20, and 29 * Abandon BW2 and seal gravel pack * Seal gravel pack in WM1, 2, 3, and 4	* Prevent affected shallow groundwater from entering Base water supply system	~
	* Rehabilitate industrial waste line in front of Building 251	* Minimize amount of exfiltra- tion from pipeline to the first mands zone	~
	* Remove manhole 33A and sesociated lines	 Prevent accumulation of sludge and eliminate potential contami- nation 	2
	· Conduct investigation on remaining Base industrial waste line	 Identify potential areas of exfiltration into the first sands zone 	c.
	* Sample monitoring wells annually and Base production wells monthly $\hat{\boldsymbol{b}}$	• Mositor wells to determine effectiveness of corrective measure	-
Off-Base Water Supply	* Inform local governmental agencies of the need to set the shoulations that require a 120-fm? Ascitary seal for new wells instrained in the area.	* Prevent new wells from provid- ing migration route between water-bearing zones	-

TABLE E.3 (Continued)

	a series and Bonitoring	Rationale	Implementation Priority
Problem			-
	· Inform local agencies of the need to seal gravel packs to a depth of 120 feet on private and public wells along affected hase boundaries	· prevent shallow of cuncerter entering water supply wells	
	· Inform local agencies of the need to mositor public and private will seminantly within a 5,000-foot bradius of affected hase boundaries	 provide early detection of downgradient migration of affected shallow groundwater 	-
	· Investigate feasibility of constructing interception system along affected	 Develop system to prevent off-base migration of affected groundwater 	

a Priorities are ranked with 1 being highest and 4 the lowest. b Wall samples should be analyzed for: volatile compound (TCE): acid compound (pentachlorophenol): base/neutral compound (1,2-dichlorobenzene).

SECTION 1

INTRODUCTION

CHAPTER 1

INTRODUCTION

BACKGROUND

The United States Air Force, due to its primary mission to militarily defend the United States through the operation and maintenance of aircraft, has long been engaged in a wide variety of operations that require handling toxic and hazardous materials. Federal, state, and local governments have developed strict regulations that require disposers of these materials to identify the locations and contents of waste disposal sites and to implement actions to eliminate any hazards to the public health or the environment. The Department of Defense (DOD) has issued Defense Environmental Quality Program Policy Memorandum 81-5 which requires the identification and evaluation of past hazardous material disposal sites on DOD property, the control of migration of hazardous contaminants, and the control of hazards to the public health and welfare that resulted from these past operations. This program is called the Installation Restoration Program (IRP). The IRP serves as a basis for response actions on Air Force installations under the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980.

The Installation Restoration Program has been developed as a fourphased program. These phases are:

- Phase I Installation Assessment.
- Phase II Confirmation
- * Phase III Technology Base Development
- Phase IV Operations

Phase I, completed at McClellan Air Force Base in July 1981, includes the identification and prioritization of past disposal sites that could pose a hazard to public health or the environment as a result of contaminant migration. Phase II consists of a comprehensive preliminary environmental survey to define and quantify the presence or absence of contamination that may adversely affect public health or the environment. This report describes the work performed during the Phase II program at McClellan AFB. During Phase III, a data base will be developed upon which to prepare a comprehensive contaminant control plan. This contaminant control plan will be implemented in Phase IV.

PREVIOUS WORK

In August 1979, the McClellan Environmental Protection Committee voluntarily created a special groundwater contamination committee to determine if aquifer water quality problems existed in the McClellan community. This action was prompted because of a problem with trichloroethylene (TCE), unrelated to McClellan AFB, in groundwater in the Rancho Cordova area, another community in the Sacramento region. initial action of the committee was to analyze water from several wells located near each corner of the Base. In early November 1979, McClellan initiated a meeting with the California Central Valley Regional Water Quality Control Board, the City and County of Sacramento, and the State Department of Health Services to discuss initial Base findings. Representatives at this meeting agreed to analyze groundwater samples on and around McClellan AFB to determine the magnitude of the problem. Monitoring of on and off-base production wells throughout November 1979 resulted in the closure of three off-base wells and two McClellan wells. Two of the off-base wells belonged to private homeowners; the third belonged to the City of Sacramento. Since that time, two additional Base production wells have been taken off-line. To respond to the situation, McClellan AFB developed a five-part investigatory program. Included were: (1) drinking water protection; (2) evaluation of past disposal practices; (3) initial identification of affected areas; (4) initial local geology and groundwater study; and (5) initial source exploration, monitoring wells, and soil borings. Under this program, fifteen monitoring wells were installed and sampled.

Phase I - Installation Assessment of the Installation Restoration Program was conducted at McClellan AFB during 1981. The Phase I study was a records search assessing the potential for groundwater quality problems on McClellan AFB, California (CH2M Hill, 1981). It provided a general description of the existing climatological, geological, and hydrological regimes at the Base and in the immediate vicinity. The Phase I report included information generated by the Air Porce in a study entitled "Investigating Ground Water Contamination as of 30 April 1981" (Brunner and Zipfel, 1981).

Forty-six active and inactive waste disposal and storage sites were identified and evaluated in the Phase I report on the basis of site characteristics, potential for contamination, waste characteristics, and waste management practices. The records search program resulted in the identification of two main areas of concern. These were (1) organic solvents found to be present in groundwater and (2) polychlorinated biphenyls (PCB's) contained in soil in a small area located at the northwest corner of the runway clear zone as a result of previous land owner activities. The soils containing PCB's were removed by the Air Force and transported to an approved PCB site. The Phase I report recommended the implementation of an expanded monitoring program to determine the extent of organic constituents in groundwater.

SCOPE OF WORK

On the basis of the Phase I Assessment of the Potential for Ground-water Contamination performed in 1981, the Installation Restoration Program, Phase II - Confirmation has been conducted. The purposes of this program have been to:

- Determine the extent and magnitude of groundwater contamination resulting from previous waste disposal practices at McClellan AFB, California
- Recommend measures to mitigate impacts for identified contaminated areas

 Develop environmental monitoring programs to document environmental conditions resulting from past waste disposal activities at McClellan AFB.

To accomplish these tasks, the ES work program included the installation of monitoring wells for collection of groundwater samples as well as the performance of hydrogeological field tests. A copy of the ES Scope of Work has been included as Appendix A to this report. Appendix B contains biographies of key ES individuals who contributed to the project.

This report presents the results of the project, including development and implementation of the field program, the sampling procedures utilized to obtain data, data analysis, conclusions, and recommendations for future actions.

Apart from this introductory section, the main report body contains five chapters. Following are brief descriptions of each chapter.

- Environmental Setting overview of regional and local hydrogeology including aquifer systems and geology as well as a description of past disposal and storage sites
- Field Program discussion of field activities and procedures entailing Stage I and Stage II drilling programs, aquifer pumping and slug tests, establishing the location of Base Well 7, and the industrial waste line survey
- Results of Field Program interpretation of hydrogeological and groundwater quality data as well as ancillary field activities
- Evaluation of Alternative Measures discussion of alternative measures for mitigation of perceived environmental problems
- Recommendations discussion of systems that have been selected as appropriate mitigation measures

The appendices that follow these chapters contain the data that were generated and detail the procedures and equipment used during the project.

SECTION 2

ENVIRONMENTAL SETTING

CHAPTER 2

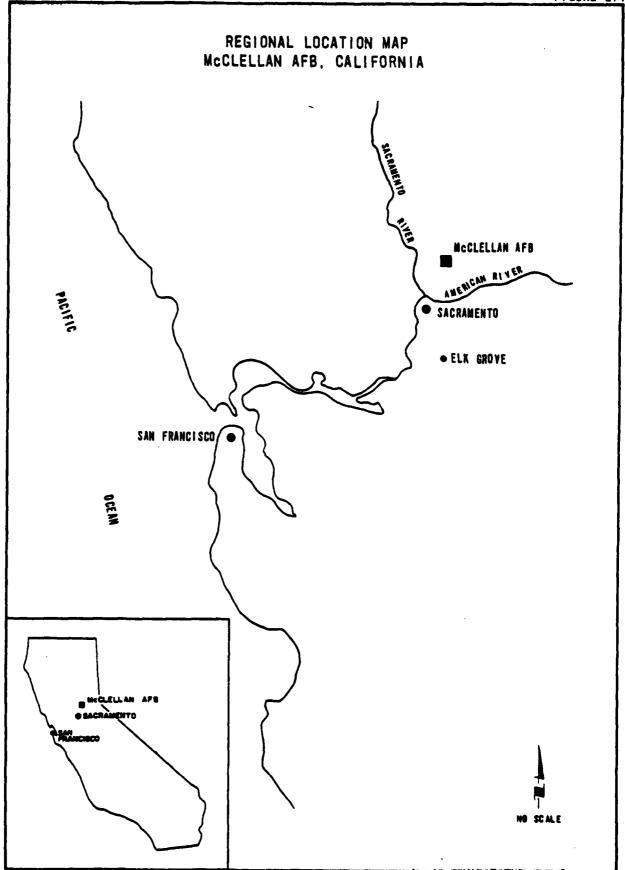
ENVIRONMENTAL SETTING

An understanding of the environmental setting at McClellan AFB was necessary to plan and execute the field program. This chapter contains a summary of the pertinent information extracted from past studies and from data sources identified by the project team. Included are discussions on (1) physical geography; (2) regional hydrogeology; (3) general hydrogeology of McClellan AFB; (4) disposal and storage areas identified in Phase I; (5) previous investigations; and (6) off-base wells. Major emphasis has been placed on the hydrogeological discussions since those areas had the greatest impact on development of the field program and subsequent interpretation of results.

PHYSICAL GEOGRAPHY

The general physical environment at McClellan AFB has been described in the Phase I report (CH2M Hill, 1981). The climatic conditions are characterized as Mediterranean-subtropical, with hot, dry summers and cool, moist winters, and an average annual rainfall of about 19 inches, most of which falls from November through May. The mean annual evapotranspiration rate for the Sacramento area is approximately 45 inches. The net precipitation for the area is approximately -26 inches per year (the difference between mean annual precipitation and mean annual evapotranspiration).

McClellan AFB encompasses 2,598 acres approximately 8 miles northeast of Sacramento, California. It has been in operation since 1936 and currently employs approximately 3,200 military personnel and 12,500 civilian employees. A regional location map is included as Figure 2.1.



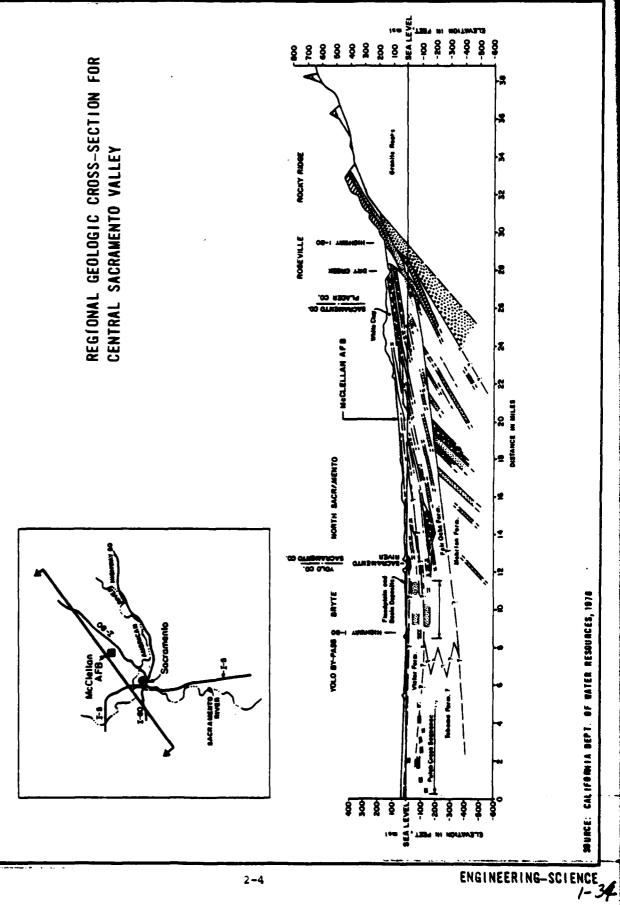
ENGINEERING-SCIENCE

The Base is located within the Sacramento River drainage basin, about 8 miles east of the river. It is locally drained mainly by Magpie Creek flowing westward through the Base to the Natomas East Main Drainage Canal and eventually to the Sacramento River. The creek follows the topographical relief from about 75 feet above mean sea level (msl) on the east, to about 55 feet above msl on the west. Near the city of Sacramento, the Sacramento and American Rivers join prior to flowing through the San Francisco Bay delta for eventual discharge into the Pacific Ocean.

REGIONAL HYDROGEOLOGY

McClellan AFB is situated within the Sacramento Valley, a deep sedimentary trough that has received sediments from the Sierra Nevadas transported downhill by numerous tributaries to the meandering Sacramento River. Since post-Eocene time (about the last 60 million years), up to 4,000 feet of nonmarine sediments and volcanic detritus have been deposited in the valley. As indicated in the geologic cross-section on Figure 2.2, the deposited sediments resemble a wedge, relatively thin by the Sierras in the east and with maximum thickness near the Coast Ranges to the west. The sedimentary wedge slopes gently to the west, ranging from 300 feet per mile to as little as 5 feet per mile in the Sacramento County area (California Department of Water Resources, 1974).

In northern Sacramento County the surface sediments are part of the Victor Formation, underlain by the Fair Oaks Formation. The Victor Formation underlies the Victor Plain, a broad alluvial plain extending from south of Sacramento to the northern county boundary. From the east this formation dips below the American River and surfaces near the Sacramento River as a low ridge with a maximum elevation of 26 feet. The top surface of the formation slopes about 5 feet per mile and the base slopes at about 11 feet per mile in an east-west direction, indicating a gradual wedging to the west. The sediments within the Victor Formation consist of interbedded granitic sand, silt, and clay with occasional lenses of metamorphic channel gravels. The sediments are heterogeneous and laterally and vertically discontinuous, indicative of a past fluviatile environment. A great variability in grain size within this unit

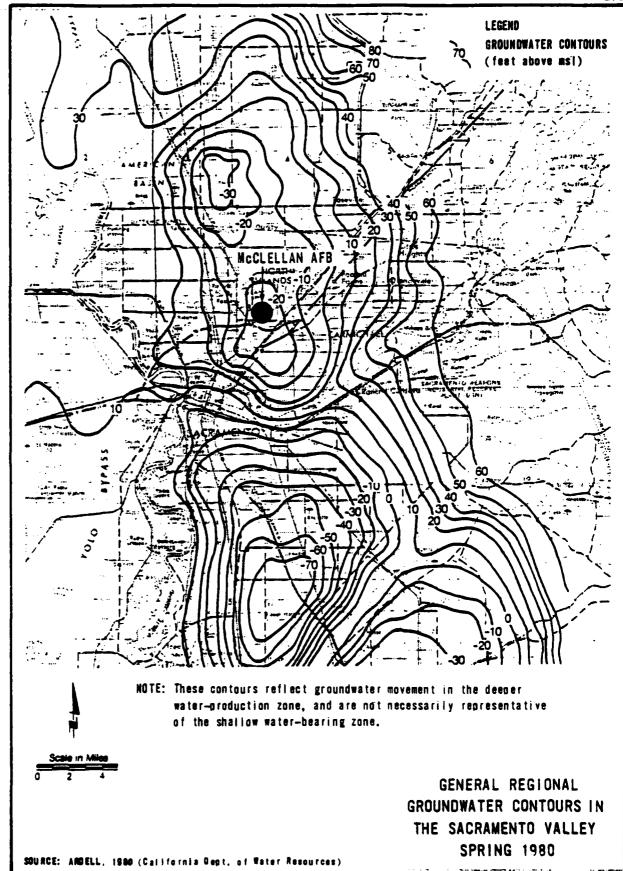


is the result of former intricately braided channels. Hardpan is usually encountered in the upper parts of the stratigraphic column. The formation has an overall moderate permeability, generally yielding little water unless old stream channels are penetrated.

The Fair Oaks Formation underlies the Victor Formation near McClellan AFB. This formation slopes westward at about 15 feet per mile, and may reach thicknesses of over 100 feet. These sediments also consist of poorly bedded silts, clays, and sands, with occasional lenses of gravel. The formation is characterized by the presence of white clay beds (white volcanic tuff) up to one foot thick. The Fair Oaks Formation, like the Victor Formation, yields little water to wells except when wells penetrate old channel deposits; in those instances, the yields may be up to 3,500 gallons per minute (gpm) with drawdowns in the order of 30 feet (i.e., specific capacities of about 120 gpm per foot of drawdown) (California Department of Water Resources, 1974).

Groundwater within the Sacramento Valley basin occurs as a result of in-stream percolation into underlying permeable materials, through direct infiltration of precipitation, or through percolation of irrigation water. The recharge areas for that part of the basin underlain by hardpan (e.g., McClellan AFB) are along the eastern basin margins; hardpan severely restricts downward movement of water, except in places where fractures exist.

Groundwater discharge occurs almost exclusively by pumping. Since the turn of the century, extensive groundwater pumping for irrigation, industrial, domestic, and municipal usage has dramatically altered the groundwater flow directions and gradients within the basin. Water is pumped primarily from the Fair Oaks and Mehrten Formations in the area around Sacramento. Figure 2.3 shows a water level contour map for 1980 in the Sacramento area, based on water level measurements in selected water supply wells throughout the Sacramento Valley (California Department of Water Resources, 1980). Since the wells used may not all have been constructed to the same depth, the water levels measured may not be representative of site-specific conditions. In addition, the measurements may represent primarily water levels resulting from confined water; shallow unconfined aquifers may exhibit different water levels



and be less influenced by regional flow regimes. As indicated on Figure 2.3, McClellan AFB is located at the northern end of a pumping trough. Groundwater within the water-bearing formations tapped by most wells would be flowing south toward Sacramento, unless other local pumping troughs influence the groundwater flow direction.

GENERAL HYDROGEOLOGY OF MCCLELLAN AFB

The general description of the hydrogeological environment of McClellan AFB provided in this section is based on published literature and information obtained from Base production wells and Base monitoring wells installed during 1980. A more detailed description of the hydrogeology is presented in Chapter 4, which discusses the results of the Phase II field program.

McClellan AFB is underlain by sediments from the Victor Formation (California Department of Water Resources, 1978). The thickness of these sediments varies, but they could be up to 50 feet thick beneath the Base. Underlying the Victor Formation is the Fair Caks Formation, more than 300 feet thick. The diagnostic white clays that characterize this formation were noticed during monitoring well installation on the western side of the Base at depths ranging from 70 to 75 feet. Sediments from the Mehrten Formation underlie the Fair Caks Formation to great depths.

Downgradient of the Base to the south, the top of the Victor Formation surfaces near the Sacramento River. The base of the formation dips beneath the river where it is eventually overlain by alluvial deposits. The Victor Formation is a wedge-shaped plain thickening from east to west, with an increase in fine-grained material in that direction (California Department of Water Resources, 1978).

Base water supply wells are completed within the Fair Oaks and Mehrten Formations at about 150 to 400 feet below the ground surface. Well logs from the installation of Base production wells are contained in Appendix C; these logs indicate great variety in subsurface conditions at each well location. Layers of sand, silt, and clay appear to

be alternating in no specific sequences or consistent thicknesses, indicating the possible discontinuous and lenticular nature of the sediments.

Geologic logs from monitoring wells installed by the Base in 1980 and subsequent water level readings in those wells have indicated water-bearing sands at an approximate 100-foot depth (about 20 feet below mean sea level). During Phase II monitoring well installation, water was also generally encountered in that depth range. Well logs for Base monitoring wells are contained in Appendix D; water level data for these wells are included in Appendix I.

A shallow water-bearing stratum at McClellan AFB consisting generally of a fine sand layer ranges in thickness from a few feet up to 17 feet. These sands contain water throughout the year, but the water levels are influenced by cyclical variations due to seasonal changes at the time of recharge. The sands are immediately underlain by either clays or silts that may be partially saturated. The shallow sands contain water under unconfined conditions.

Deeper water-bearing materials are separated from the shallow sands by extensive thicknesses (up to 60 feet) of silts and clays that act as confining layers; thus, the water encountered at greater depths is confined. The water supply wells on the Base tap these deeper sands for water.

An old now-buried stream channel, a former branch of the North Fork of the American River, appears to cross the eastern part of the Base trending in a northeast to southwest direction (California Department of Water Resources, 1974). This former channel is about 20 feet wide and located at depths over 100 feet; it contains considerable amounts of gravel and occasional boulders, and is a productive zone for groundwater. These channel deposits are probably located below the shallow water-bearing sands. Zones of higher permeability than surrounding material could act as conduits for constituent migration, serving as "channels" with water traveling at higher velocities in a downgradient direction.

The regional groundwater flow direction is to the south-southwest toward a pumping trough south of Sacramento. South and west of McClellan AFB are numerous active private and public water supply wells that influence the immediate subregional groundwater flow. Limited data indicate that these wells are completed at depths ranging from 125 feet to 210 feet, thus reaching into deeper water-bearing sands. The shallow water-bearing sands seem to be less influenced by the regional gradient dominated by surrounding pumping practices, and appear to have water flowing in a more southwesterly direction than the regional flow.

The recharge areas for the water-bearing sands underlying McClellan AFB are east of the Base in the Sierra Foothills. Recharge for the shallow sands is located closer to the Base than the recharge areas for the deeper water-bearing sands. Discharge from the groundwater basin would normally occur to the west into the Sacramento River. However, due to the creation of the pumping trough south of Sacramento, all groundwater underlying McClellan AFB either will discharge to wells near Sacramento or will increase groundwater storage in this vicinity.

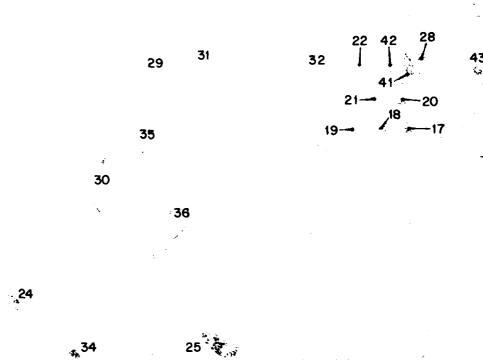
DISPOSAL AND STORAGE SITES IDENTIFIED IN PHASE I

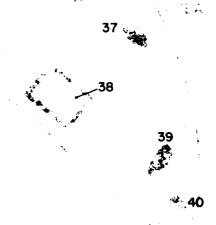
Forty-six waste disposal and storage sites were identified and evaluated in the Phase I report (CH2M Hill, 1981). The estimated locations of these sites are illustrated on Figure 2.4. Table 2.1 delineates each site, along with information obtained from historical records and personnel interviews regarding site usage, period in use, materials handled, and estimated site size. It should be noted that not all these sites contain materials designated as hazardous.

The Phase I evaluation of these sites was based upon site characteristics, potential for contamination, waste characteristics, and waste management practices. The evaluation was performed using a site rating model developed in June 1981, and consisted of assigning to each site numerical values weighted on a subjective scale according to degree of severity for contamination potential. Based upon these numerical evaluations, the sites were assigned either a high, medium, or low priority ranking. Table 2.2 contains a delineation of the sites broken

FIG 2.4

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LEGEND

Disposal/Storage Areas 21

> NOTE: Description of each Site is found in Table 2.1

₹ 5 - 45

LOCATION OF DISPOSAL AND STORAGE SITES McCLELLAN AFB, CA

ENGINEERING-SCIENCE

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2-10

TABLE 2.1

DISPOSAL AND STORAGE SITES IDENTIFIED IN PHASE I MCCLELLAN AFB, CALIFORNIA

Site	Prior Use	Dates in Use	Probable Materials Handled	Estimated Site Size
-	Burning/burial pit	1959 - 1962	Refuse/solid waste	310 ft x 190 ft
~	Sludge/oil pit Refuse burning/burial	1962 - 1979	Refuse/solid waste Undewatered industrial sludge Oil Waste solvents TCE-contaminated wastes	300-400 ft x 50 ft x 30 ft deep
m	Sludge/burning/ burial pit	1962 - 1965	Undewatered industrial sludge oil	300-400 ft x 50 ft x 30 ft deep
•	Sludge/oil pit	1967 - 1981	Undewatered industrial sludge Oil TCE-contaminated wastes	300-400 ft x 50 ft x 30 ft deep
w	Sludge/oil pit	1972 - 1978	Undewatered industrial sludge Oil Waste solvents TCE-contaminated wastes	300-400 ft x 50 ft x 30 ft deep
•	011 burn pit	1972 - 1978	011 Fuel Solvents	125 ft n 125 ft
~	Sludge/oil pit	1966 - 1977	Undewatered industrial sludge Oil TCE-conteminated wastes	300-400 ft x 50 ft x 30 ft deep
80	Sludge/burial pit	1974 - 1981	Devatered industrial sludge Desolition debris Creek debris Paint chips and residues Santary seeage sludge (grit) TCE-conteminated wastes	400 ft x 40 ft x 30 ft deep.

TABLE 2.1 (Continued)

Site	Prior Use	Dates in	983	Probable Materials Mandled	Estimated Site Size
o	Burial pit	Pre-1949 - 1953	- 1953	Ash and partially burned residue from Sites 22 and 31 Dewstered industrial wastewater treatment plant sludge plant sludge Plating bath solutions and sludges (including lead, tin, antimony, and possibly cadmium plating wastes) Degressing solvents and sludges Paint residues Fuels (probably including leaded) and oils PCB liquids, solids, transformers, and electrical components Miscellaneous laboratory chesicals Cyanide wastes (drummed) Low-level radioactive wastes (possibly) Herbicide/pesticide containers	100-400 ft x 50 ft x 30 ft deep
01	Burial pit	1953 ~ 1955	55	Same as Site 9	100-400 ft x 50 ft x 30 ft deep
Ξ	Burial pit	1955 - 1957	151	Same as Site 9	100-400 ft x 50 ft x 30 ft deep
13	Burial pit	1967 - 1969	696	Same an Site 9	100-400 ft x 50 ft x 30 ft deep
13	Burial pit ^b	1969 - 19	1761	Same as Site 9	100-400 ft x 50 ft x 30 ft deep
:	Burial pit	1971 - 1974	974	Same as Site 9	100-400 ft x 50 ft x 30 ft deep
51	Sodium valve trench	1940 - 1950	950	Sodium valves from aircraft engines	15-20 ft x 2 ft x 6-9 ft deep
91	Sodium valve trench	1940 - 19	1950	Sodium valves from aircraft engines	15-20 ft x 2 ft x 6-9 ft deep
17	Burtal ptt	1957 - 1959	959	Same as Site 9	100-400 ft x 50 ft x 30 ft deep
18	Burial pit	1957 - 19	1959	Same as Site 9	100-400 ft x 50 ft x 30 ft deep
19	Burial pit	1957 - 1959	959	Same as Site 9	100-400 ft x 50 ft x 30 ft deep
70	Sludge/oil pit	1956 - 1957	15.7	industrial wastewater treatment plant sludge Oil	250 ft x 190 ft
~	Sludge/oil pit	1956 - 19	1957	Industrial wastewater treatment plant sludye Oil	250 ft n 220 ft
22	Burning pit/ teepee burner/ burial pit	1946 - 1968	896	Refuse, ash and residue Oily wastes Maste solvents (including TCE in significant amounts Maste chemicals	100 ft x 400 ft x 50 ft
23	Burial pit	1966 - 19	- 1969 ^d	No information available	125 ft x 280 ft
₹	Burning/burial pit	1964 - 1969	696	Demolition debris Scrap material (lumber and paper)	310 ft x 160 ft

TABLE 2.1 (Continued)

Site	Prior Use	Dates in Use	Probable Materials Handled	Estimated Site Size
\$	Burtal pit	1940's and early 1950's	No information available	625 ft x 250 ft
5 6	Sludge pit	Early 1960's	Undewatered industrial sludge	300-400 ft x 50 ft x 30 ft deep
2.1	Sodium valve trench	Late 1940's and early 1950's	Sodium valvam from mircraft anginem	15-20 ft x 2 ft x 6-9 ft deep
58	Creek debris sludge pit	Pre-1972	Creek debris/sediments Industrial waste spills and discharges (probably)	160 ft x 250 ft
53	Civil Engineering reclamation yard, transformer storage area, and scrap material burner	1950's and 1960's	Drums Transformers (some with PCB's)	160 ft x 250 ft
	Generator burial pit	1974	Aircraft generators (*50 - 60)	
30	Surface disposal site	Late 1950's - present	TCE Freon D'sthyl ether Low-level radioactive wash water	220 ft x 220 ft
Ξ	Refuse incinerator/	1963 - 1968	Refuse/solid waste	160 ft x 250 ft
35	Radioactive/hazardous waste storage	Pre-1963 - 1975	Low-level radioactive waste containers	160 ft x 160 ft
3	Industrial sludge landfarm	1972	Industrial waste treatment sludge	350 ft x 250 ft
3,	Waste solvent storage tanks	1.50 - 1953	Waste solvents (2 underground tanks)	310 ft x 125 ft
35	Scrap metal burial pit	World War II	Scrap strapping steel	220 ft x 160 ft
36	Open storage area	1958 - 1980	Plating shop chemicals	125 ft x 190 ft
37	Burial pit	Early 1950's	Refuse	500 ft x 250 ft
86	Engine repair shop; carbon remover storage/burial/ sludye pits	1940's . mid 1960's	Carbon remover, including ethylene dichloride/cresylic acid/soap emulsion mixture and 50-50 mixture of cresylic acid/orthorichlorobenzene (large quantities in above and below-ground tanks) Contaminated carbon removal sludges from skimming ponds	875 ft x 595 ft
39	Burning/Iwrial pit	Pre-1941 - 1946	Refuse/ash All Base Vastes	625 ft x 160 ft

TABLE 2.1 (Continued)

Site	Site Prior Use	Dates in Use	Probable Materials Handled	Estimated Site Size
\$	Industrial aludge drying beds (0, unlined)	1955 - 1972; 1980	Industrial wastewater treatment plant sludges in 4 beds (probably with significant concentrations of VOC's)	250 ft x 190 ft
=	Burial pit	Mid-1940's	Demolition debria (probably)	560 ft x 190 ft
7	Oil atorage/burning/ burial pita (3 parallel burial pita and 2 burning	1960's -	Oli Waste fuel Waste golvents Refuse	190 ft x 310 ft
7	Burial pit	Mid-1940's	Demolition debris (probably)	220 ft x 250 ft
;	Magardous waste storage area	1975 - present	No information available	500 ft x 150 ft
45	Paint burial pit	1950's	Latex-based(?)paint (~200-300 55-gallon drums) 560 ft x 160 ft	560 ft x 160 ft
46	Salvage yard operation (under previous owner)	Mid-1960's -	No information available (identified PCB surface contamination; possible burial pit)	500 ft x 375 ft

Sources: CH2M Mill, 1981 and Department of the Air Force, 1979

a Bite locations are allown on Figure 2.4.
b Fire training is currently conducted in the vicinity of the site.
c Cyanide wastes were possibly removed from Site 12 or 13 during 1967-1971.
d Material was removed in 1970.
e Temporary (2 to 4 months).
f Material was removed in 1950.
g Material was removed in 1956.
h Material was removed in 1956.

TABLE 2.2

PHASE I PRIORITY LISTING OF

McCLELLAN AFB DISPOSAL AND STORAGE SITES

Site No.	Site Description	Overall Score 1981	HARM Score 1982
	HIGH PRIORITY:	<u>59 - 72</u>	
Site 4	Sludge/oil pit	72	86
Site 2	Sludge/oil pit	71	86
Site 3	Sludge/burning/burial pit	71	86
Site 5	Sludge/oil pit	71	86
Site 6	Oil burn pit	71	86
Site 26	Sludge pit	71	86
Site 7	Sludge/oil pit	67	85
Site 8	Sludge/burial pit	66	85
Site 22	Burning pit/teepee burner/burial pit	66	81
Site 40	Industrial sludge drying beds	66	69
Site 17	Burial pit	65	71
Site 18	Burial pit	65	71
Site 19	Burial pit	65	71
Site 38	Engine repair shop	65	81
Site 20	Sludge/oil pit	64	81
Site 21	Sludge/oil pit	64	81
Site 9	Burial pit	63	75
Site 10	Burial pit	63	75
Site 11	Burial pit	63	75
Site 12	Burial pit	63	75
Site 13	Burial pit	63	75
Site 14	Burial pit	63	75
Site 1	Burning/burial pit	61	70
Site 46	Salvage yard operation	61	86
Site 39	Burning/burial pit	60	70
Site 42	Oil storage/burial/burning pits	59	75

TABLE 2.2 (Continued)

Site No.	Site Description	Overall Score 1981	HARM, Score 1982
	MEDIUM PRIORITY:	43 - 52	
Site 33	Industrial sludge landfarm	52	72
Site 32	Radioactive/hazardous waste storage	51	N.R.C
Site 27	Sodium valve trench	50	N.R.
Site 28	Creek debris sludge pit	50	65
Site 30	Surface disposal site	50	67
Site 41	Burial pit	49	N.R.
Site 43	Burial pit	49	N.R.
Site 15	Sodium valve trench	44	N.R.
Site 16	Sodium valve trench LOW PRIORITY:	44 34 - 42	N.R.
Site 29	Civil Engineering reclamation yard	42	N.R.
Site 45	Paint burial pit	42	41
Site 31	Refuse incinerator	41	N.R.
Site 34	Waste solvent storage tanks	38	N.R.
Site 24	Burning/burial pit	37	N.R.
Site 25	Burial pit	37	N.R.
Site 23	Burial pit	35	N.R.
Site 35	Scrap metal burial pit	34	N.R.
Site 37	Burial pit	34	N.R.

a CH2M Hill, 1981

down by these rankings. As indicated on this table, most of the sites were originally assigned to the high priority classification. In January 1982, a new site rating model was developed by the Air Force to more realistically evaluate the potential hazards posed by sites at Air Force installations. This new Hazard Assessment Rating Methodology (HARM System) was designed to improve the ranking of sites with regard to potential environmental contamination. The HARM scores for those

b USAF Installation Restoration Program Hazard Assessment Rating Methodology, 1982

c N.R. - Not rated

sites which were reevaluated by the Air Force using this revised methodology are also presented on Table 2.2.

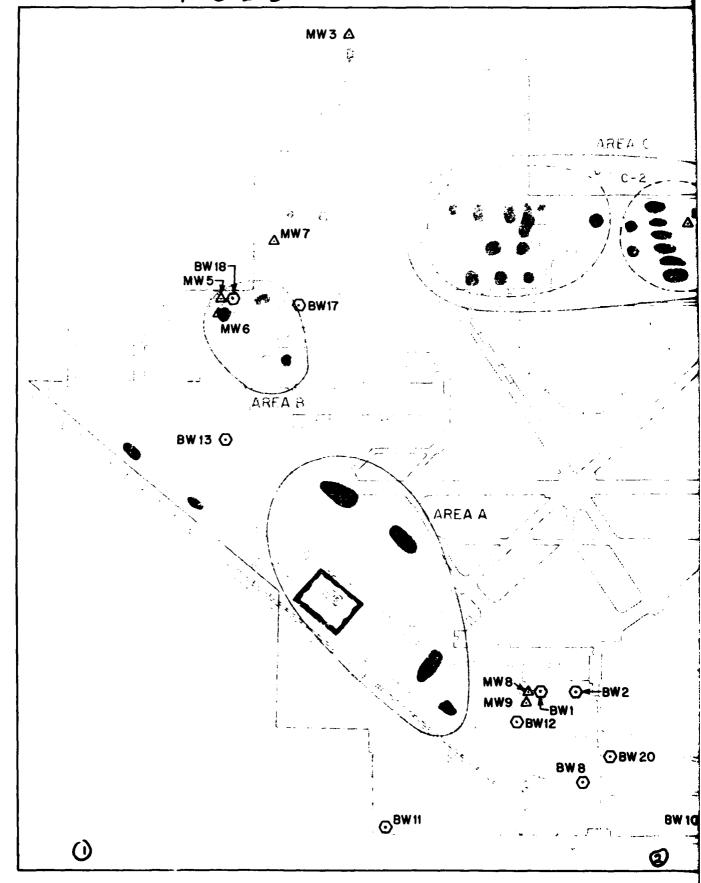
PREVIOUS INVESTIGATIONS

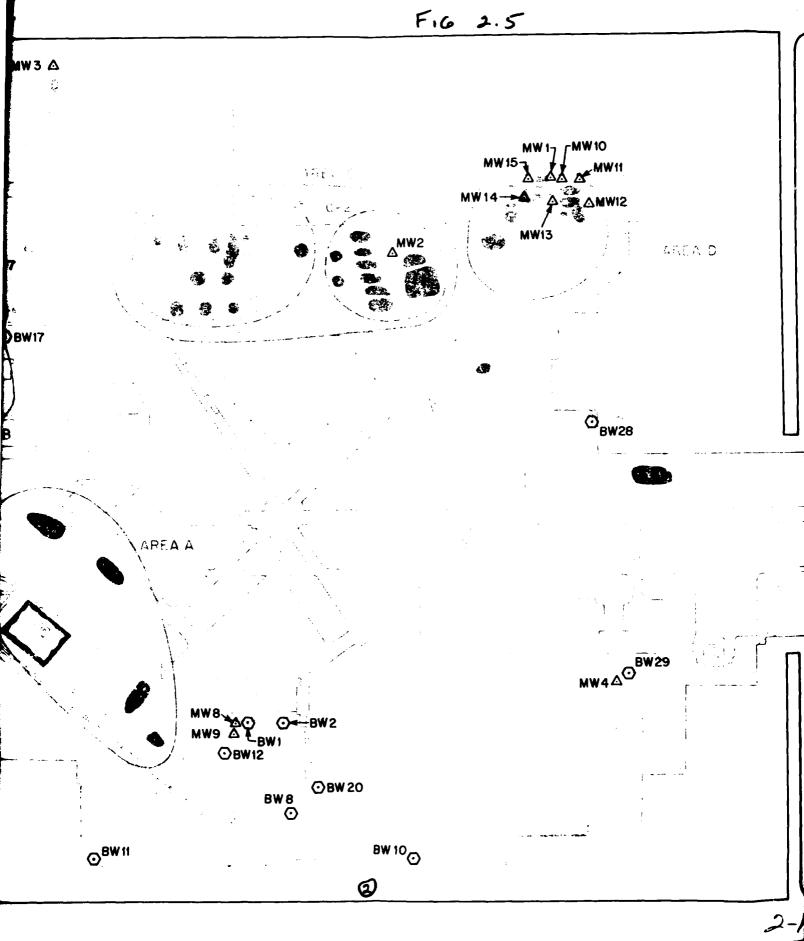
In August 1979, a Groundwater Contamination Committee was established by McClellan AFB to identify potential groundwater quality problems on the Base. As a result, on-base water supply wells were sampled for volatile organic compounds (VOC) and a number of groundwater monitoring wells were subsequently installed. The locations of the Base production wells and Base monitoring wells are shown on Figure 2.5.

Analysis of groundwater samples for volatile organic compounds over time showed that trichloroethylene (TCE) was the constituent most frequently identified. With this the case, TCE could be expected to serve as an indicator of the presence or absence of volatile organics in groundwater. Table 2.3 summarizes the chronology of the groundwater quality problems on the Base following initial identification of trichloroethylene (TCE) during an August 1979 sampling event. As represented on the table, chemical constituents were identified in BW1, BW2, BW12, BW13, and BW18 and MW1, MW2, MW3, and MW4. Table 2.4 presents analytical data for TCE for these wells prior to Phase II.

During installation of MW12, MW13, and MW14, solid material samples were obtained and analyzed for volatile organic compounds. The results of these analyses are depicted on Figure 2.6. In material from MW12 and MW13, most of the detected constituents were in the range of 100 to 400 $\mu\,\mathrm{g/kg}$. MW14, which was installed through Site 2, showed high levels of 1,1,1-trichloroethane and trichloroethylene in samples from depths of twenty feet and forty feet.

Available well logs and well designs for Base production wells and Base monitoring wells are contained in Appendices C and D. Information for these wells regarding depths of casing, seals, gravel packs, and casing perforations is summarized in Table 2.5. These parameters are important for determination of the potential mode of transportation of constituents within the aquifer system underlying the Base.







LEGEND

△MW2 Monitoring Wells Installed 1980 and

1981

⊙^{BW2} Base Production Wells

MW 15 - MW 10 MW 14 - A A A A MW 12 MW 13

⊙_{BW28}

MW4 AO

LOCATION OF
BASE PRODUCTION WELLS
AND MONITORING WELLS
McCLELLAN AFB, CA

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BW 10

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DBW 20

TABLE 2.3

CHRONOLOGY OF EVENTS AT MCCLELLAN APB PRIOR TO PHASE II

9000		Regult
August 1979	* Initial mampling of B410, B411, B416, and B428	• BW10; no TCE detected • BW10; no TCE detected • BW10; TCE = 3.9/4.5 ppb (split sample) • BW20; trace of TCE found
November 1979	· Sampling of numerous on and off-base supply wells	 Buf and BW2 taken off-line Two private wells closed (Higgs and Russell) One City of Sacramento well closed (Well 150)
January 1980	• Bw1 mampled frequently; other Base wells mampled	* BW1 found to contain traces of TCE * BW1 placed back on-line * BW18: TCE = 12 ppb
March 1980	• MW1 sampled during eight hours of continuous pumping	• BH1: TCE values range from 1.3 to 716 ppb/ carbon tetrachloride values range from 0.5 to 38 ppb • BH1 taken off-line
April 1980	 Sampling continued on Base wells Construction begun on HM1, HM2, HM3, HM4 	* Bw12; TCE = 8 ppb
May 1980	• Open sludge pit sampled and analyzed for volatile organic compounds	• Material from open aludge pit found to contain: TCE = 29,600 ppb tricklorosthane = 34,000 ppb dichlorosthane = 49,600 ppb tatrachlorosthylene = 23,200 ppb toluene = 315,000 ppb naphthalene = 46,800 ppb
June 1980	• Construction complete on MVI, MV2, MV3, and MV4 • Weekly sampling and analysis program begun on monitoring wells	* MW3: soil at 200-ft depth contained TCE = 100 Hg/kg and dichloroethylene = 3.8 Hg/kg * MW1 and MW2: TCE = <4.5 ppb
July 1960	• Sampling continued on Base wells	* BW1: TCE = 100 ppb dichloroethylene = 49 ppb dichloroethane = 4.2 ppb trichloroethane = 4.2 ppb Preon = 99 ppb

TABLE 2.3 (Continued)

Date	Event	Reput t
	· Sampling continued on monitoring wells	* Mel and Mel consistently show levels of TCE >4.5 ppb
August 1960	. Sampling continued on Base wells	• BW2; TCE = 110 ppb • BW12; TCE = 35 ppb • BW12 taken off-1ine • BW12; TCE = 8 ppb
	· Sampling continued on monitoring	MM1 and MM2 consistently show levels of TCE >4.5 ppb MM3; TCE = 1.9 ppb (4 August only) MM4; TCE = 2.2 ppb (4 August only) semaining open sludge pit closed to
	 Sampling performed at selected aquifer levels on MN1 and MN2 	MI: dichlorobensene = 126 ppb bis(2-ethylhexyl)phthalate = 10 ppb M2: bis(2-ethylhexyl)phthalate = 15 ppb
September to November 1980	• Additional monitoring wells installed (MMS-9)	* MW8: Soll at 100-ft depth contained TCE = 36 µg/kg
Pebruary/ March 1981	• Sampling continued on Base wells • FM1 plugged all the way to the surface • FM2 plugged from 249-ft to 60-ft denth below surface	• BW18: TCK = 9 ppb
May 1981 June 1981	* Sampling continued on Base wells	* BW12: TCE = 27 ppb
July 1981	* Sampling continued on Base wells	BW12, TCE -
	. DWI sampled at various levels . IRP Phase I completed	* BWIG, TCE * 63 ppb * BWI, TCE * 1,300-2,000 ppb at all perforation levels
July/August 1981	• MM10-15 constructed (soil only)	* Mild: Soil at 20-ft, 40-ft, 50-ft, and 60-ft depths contained high levels of various solvent compounds
Movember 1981	· BWI2 sampled at various levels	• BW12: TCE = 3.9-73 ppb throughout water column
December 1981	. IRP Phase II initiated	

a All constituents were measured in groundwater unless otherwise noted.

TABLE 2.4 DETECTED TCE CONCENTRATIONS IN BASE MONITORING WELLS PRIOR TO PHASE II a (ppb)

1	mpling Date 1980	mw1 ^b	MW2 ^b	MW3 ^C	MW4 ^C
11	June	_d	-	<0.5	•
12	June	1.8	-	•	-
18	June	1.1	0.2	<0.5	0.1
24	June	2.9	0.8	<0.5	<0.5
3	July	11.0	1.4	<0.5	<0.5
	July	19.0	1.6	<0.5	<0.5
15	July	36.0	1.6	<0.5	<0.5
25	July	62.0	2.4	<0.5	1.4
	July	110.0	2.9	<0.5	<0.5
31	July	61.0	2.6	<0.5	<0.5
1	August	68.0	2.3	<0.5	<0.5
4	August	2.1	2.1	1.9	2.2
5	August	71.0	4.7	0.2	<0.5
6	August	92.0	4.2	<0.5	<0.5
7	August	68.0	2.9	<0.5	<0.5
8	August	78.0	<0.5	<0.5	<0.5
11	August	70.0	3.4	<0.5	<0.5
12	August	90.0	2.8	<0.5	<0.5
13	August	100.0	3.0	<0.5	<0.5
14	August	88.0	3.3	<0.5	<0.5
15	August	28.0	2.8	<0.5	<0.5
21	August	78.0	4.6	<0.5	<0.5
25	August	•	1.6	<0.5	<0.5
27	August	-	8.8	-	-
28	August	32.0	-	•	-
7	October	-	-	<0.5	<0.5
28	October	-	-	<0.5	<0.5
6	November	-	-	<0.5	<0.5

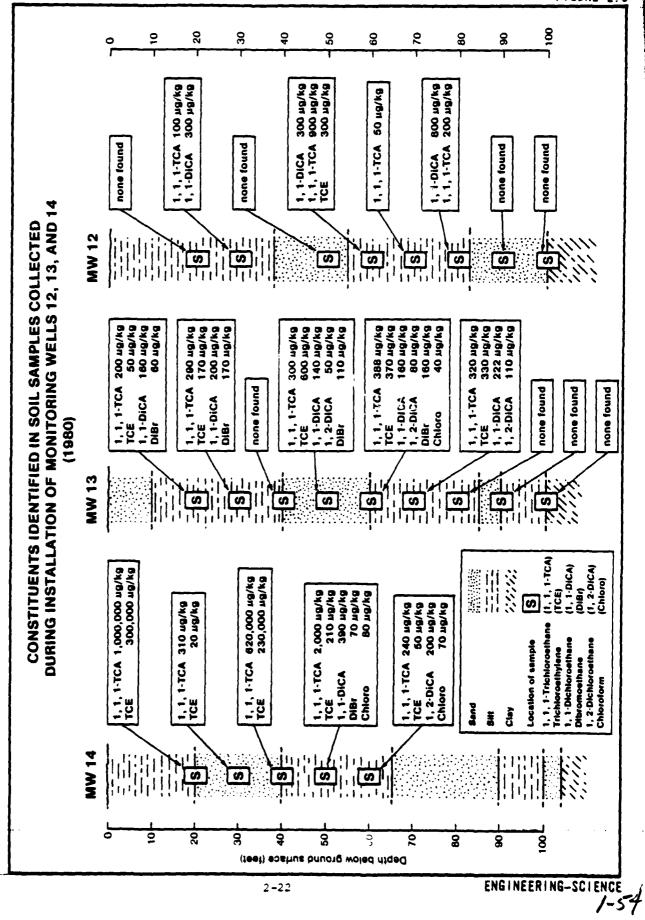
Source: Brunner and Zipfel, 1981

a Pumping at approximately 200 feet plus.

b Volatile organic compounds (VOC) other than TCE were found during some analyses in monitoring wells 1 and 2; however, TCE was the predominate constituent.

c Monitoring wells 3 and 4 have been continually free of VOC contamination.

d(-) = not sampled



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TABLE 2.5

WELL DESIGN SPECIFICATIONS FOR WELLS IN WHICH CONTAMINATION WAS IDENTIFIED DURING INITIAL SAMPLING EVENTS FROM 1979 TO 1981

MCCLELLAN AFB, CALIFORNIA

	Depth of	Depth of	Depth of First	Depth of
Well	Casing (feet)	Gravel Pack (feet)	Perforations (feet)	Seal (feet)
BW1 ^a	400	0-400	162	0-36
BW2	404	0-404	100	0-40
BW12	390	0-390(?)	164	0-50
BW13 ^D	391	0-391(7)	178	0-50
BW18	404	0-404	169	0-50
MW1 ^C	249	75-249	75	0-75
MW2	249	75-249	75	0-75
MW3	205	70-205	70	0-70
MW4	249	85-249	85	0-85

a BW - Base production well

Generally, the first water-bearing sands beneath McClellan AFB are encountered at depths between 80 feet and 100 feet below the ground surface, with the next water-bearing material at depths reaching 160 feet. Table 2.5 indicates that the first perforations in the sampled Base production wells occur at depths ranging from 100 to 178 feet, and occur between depths of 70 and 85 feet in the four Base monitoring wells installed in April 1980 (MW1, MW2, MW3, and MW4). Gravel packs extend from the ground surface for the entire depths of the production wells, with grout seals around the perimeter of the gravel packs to a maximum depth of 50 feet. The sampled Base monitoring wells all reach depths exceeding 200 feet. Each monitoring well was gravel-packed from the water table (beginning at depths of 70 to 85 feet below the surface) to the bottom of the well, with grouting extending from the ground surface to the water table. The constituents identified in the groundwater could have migrated into the wells either through the perforated casing intervals or through the gravel packs. Since both the production wells and the monitoring wells have either perforations or gravel packs in the

b No logs available

c MW - Base monitoring well

shallow groundwater zone, constituents identified could be present in the shallow zone only, the deeper zones only, or in all zones. The schematic drawing on Figure 2.7 illustrates potential modes of contaminant migration through a gravel-packed well that is perforated within several water-bearing strata, and where constituents are concentrated in a shallow aquifer. If migration has occurred through the casing perforations, the implication would be that the constituents are contained in the deeper aquifers being tapped by the wells; if the constituents are contained shallow aquifer, they may have traveled to the deeperlying aquifers through the gravel pack surrounding the casing.

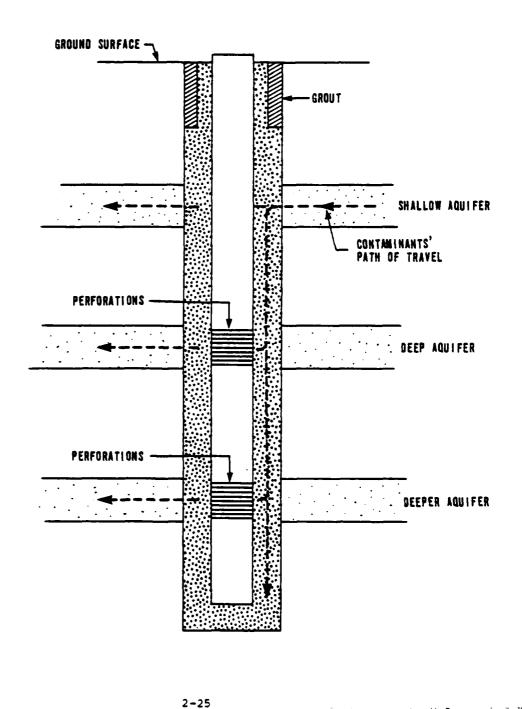
OFF-BASE WELLS

Off-base production wells located to the west and southwest of the Base have been sampled since 1979 as a result of trichloroethylene (TCE) being detected in groundwater samples from some Base wells. The locations of the surrounding off-base city and private wells are shown on Figure 2.8. Table 2.6 shows the sampling history for some of these wells and their associated constituent concentrations. During November 1979, groundwater analysis was performed for volatile organic compounds (VOC), leading to the subsequent closure of three off-base wells. Two of the wells were owned by private households (Higgs and Russell), and the third (CW150) belonged to the City of Sacramento. The depth of the Higgs well was 80 or 90 feet; the city well pumped from 144 to 372 feet. A new well constructed by Higgs has not been found to contain any volatile organic compounds. Several other off-base wells owned by the City of Sacramento have shown the presence of TCE, although information is Chloroform, a trihalomethane, was found in several private wells west of the Base.

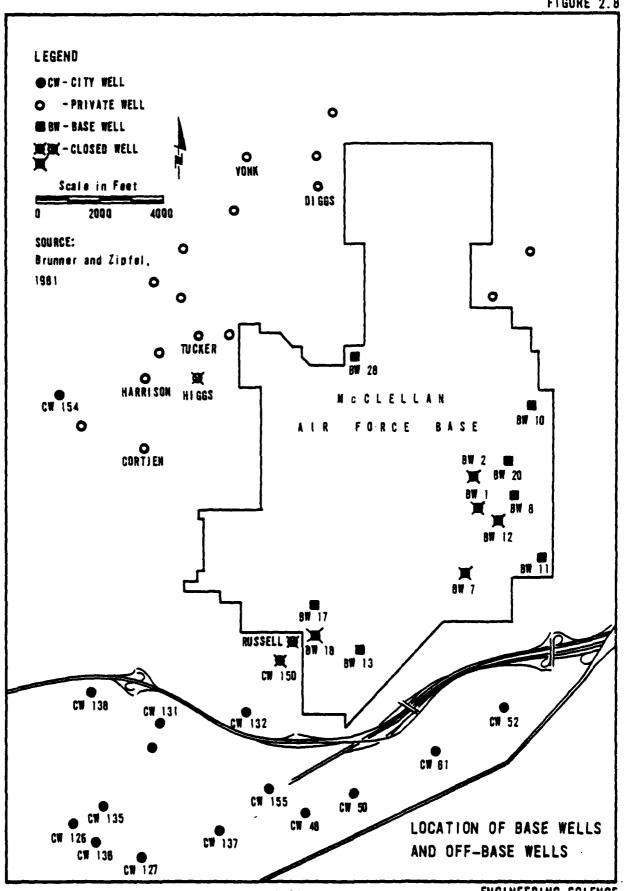
SUMMARY

The net precipitation for the Sacramento area is about -26 inches per year, based on an annual rainfall averaging 19 inches and a mean annual evapotranspiration rate of approximately 45 inches.

CONCEPTUAL SCHEMATIC OF POSSIBLE MODE OF MIGRATION OF CONTAMINANTS IN TYPICAL GRAVEL-PACKED BASE PRODUCTION WELL AT McCLELLAN AFB, CA



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TABLE 2.6

VOLATILE ORGANIC COMPOUNDS IDENTIFIED IN GROUNDWATER SAMPLES FROM OFF-BASE WELLS (concentrations in ppb)

				Compound			
Well and Sampling Date	Trichloro- ethylene (TCE)	Chloro- form	1,1-d1- chloroethylene	1,2-trans- dichlorosthylene	1,2-di- chloroethylene	1,2-di- chloroethane	Tri- chloroethane
City Well 150							
(M. Berbers St.)							
13 Nov 1979	f. 3	1	•	1		1	•
14 Nov 1979	5.8	•	•	2.3	•		1
21 Nov 1979	7.3	1	•	•	•	•	1
27 Feb 1980	5.1	ı	,	1		,	
3 Mer 1980	5.1	1	•	1	•	•	,
10 Mar 1980	6.1	•	,	1	•	•	•
17 Jul 1981	6.1	•	•	1	•	•	•
	<0.25	1	ı	•	•	r	•
23 Jun 1982	0.30	•	,	ı	•	•	•
24 Jun 1982	0.60		1	1	1	•	•
25 Jun 1962	2.3	ı	•	1	•		,
29 Jun 1962	-:	•	1	,	•	•	•
30 Jun 1982	1.7	1	•	•	•	•	•
1 Jul 1982	2.7	•	1	1	•	•	•
2 Jul 1982	1.7		•	1	•	•	,
3 Jul 1982	1.6	1	•	1	•		•
	6.0	1	•	•	•	1	•
5 Jul 1982	4.7	•		•	,	•	1
11 998							
(5632 20th st)							
9 Nov 1979	•	2	Q	2	Q.	Ç	Q.
19 Nov 1979	31	9	ş	9	Ç	2	皇
29 Nov 1980	₩.	0 .0	₽.	9	7 .0	98	.
Hev Well							
15 Jan 1960	2	2	Q	2	9	2	Ş
12 Bep 1980	2	2	2	2	2	2	2
19 Jan 1981	QM	£	QN	Q	2	Q	2
Russell							
(2248 Bell St) 15 Mov 1979	13.1	2.5	9	2	ş	ş	ş
		;	Ì	2	•	È	È
(Jemine and Ive)							
15 Nov 1979	2.7	æ	1	ŧ	•	1	1

TABLE 2.6 (Continued)

				Compound			
Well and Sampling Date	Trichloro- ethylene (TCE)	Chloro- form	1, 1-d1- chloroethylene	1,2-trans- dichloroethylene	1, 2-d1- chloroethylene	1,2-di- chloroethane	Tri- chloroethane
City Well 138							
13 Hov 1979	3.0	1	•	1	•	•	
14 Nov 1979	61.0	1	•	- :-	1	,	•
15 Nov 1979	3.6	•	•	<u>.</u>	•	1	ı
City Well 116 (702 Plaza St.)						- ·	
20 Nov 1979	1.2	•	•	•	•	•	•
Vonk							
(6645 22nd St)	ş	ç	á	ş	ş	Í	ŝ
29 Jan 1980	Q	2 2	2	2	9	2 2	2 2
Marrison (1920 C St)							
15 Nov 1979	Q	25.4	2	2	£	9	2
27 Feb 1980	9	ð	£	QN	9	9	ON.
19 Jan 1981	Q	9	9	QN	Q.	2	9
(1919 Ascot)							
19 Nov 1979	Q	4 6	9	ş	9	2	2
27 Feb 1980	QN	Q.	Q	Q.	g u	Ç	2
Tucker (5749 24th St)							
19 Nov 1979	<u>Q</u>	29.0	£	£	g	Q	Q N
(6500 24th St.)	Í	į	•	•	!	;	;
600 1979 600 1979	È	7.67	2	2	2		<u>a</u>
18 March 1982	<0.05	t	ı	1	,	•	•
18 March 1982	<0.0>	•	ı	ı	•	ı	,
16 March 1982	<0.05	i	•	•	•	ı	'n

ND = not detected (-) - sample not analyzed for this compound

The Sacramento Valley consists of a sedimentary trough containing about 2,000 to 4,000 feet of material deposited in the form of a wedge thickening from east to west, with increasingly finer-grained materials deposited to the west. The sediments consist of poorly bedded silts, clays, and sands, with occasional lenses of gravel. Water is contained primarily in discontinuous stream channel deposits at depths of 150 to 400 feet. Groundwater discharge for the Sacramento basin occurs almost exclusively by pumping. There is no discharge to the ocean or other large surface water body.

Base water supply wells are completed within the Fair Oaks and Mehrten Formations about 150 to 400 feet below the surface. Logs from these wells and from Base monitoring wells indicate a great variety in subsurface conditions at each well location. Layers of sand, silt, and clay appear to be alternating in no specific sequences or consistent thicknesses, indicating the discontinuous and lenticular nature of the sediments. Beneath McClellan, shallow water-bearing sands occur at an approximate 100-foot depth; the flow direction in the shallow sands is toward the south-southwest, while the regional groundwater flow is toward the southwest.

Forty-six former waste disposal and storage sites were identified at McClellan during IRP Phase I. Most of the disposal sites were located in the northwestern corner of the Base and near the boundary of the Base west of the runway. A ranking of the sites based on site characteristics, potential for contamination, waste characteristics, and waste management practices assigned the majority of identified sites to the high priority classification. The sites were subsequently reevaluated by the Air Force using its improved Bazard Assessment Rating Methodology.

Analysis of soil samples from soil borings completed in the north-western corner of the Base showed detectable levels of volatile organic compounds to depths of 80 feet. In November 1979 on-base and off-base production wells were sampled; volatile organics were found, and BW1 and BW2 were taken off-line. Three off-base wells were closed, including two private wells and one city well, at distances of 250 to 1,000 feet from the Base boundary. In August 1980, BW12 was taken off-line; BW18

was removed from production in June 1981. In April 1980 McClellan installed four monitoring wells at the northwest, southwest, and northeast corners of the Base. Samples from MW1 and MW2 in the northwest corner contained varying levels of TCE. In February and March 1981, MW1 and MW2 were plugged. In 1980 and 1981 an additional 11 monitoring wells were installed by McClellan AFB, primarily in the northwestern part of the Base at a depth of 105 feet.

SECTION 3

FIELD PROGRAM

CHAPTER 3

FIELD PROGRAM

An extensive field program was developed for McClellan AFB. Field activities included the installation of groundwater monitoring wells within different subsurface water-bearing zones. The purposes of monitoring well installation were to obtain site-specific hydrogeological data and to collect samples for analysis of chemical constituents contained in groundwater within the Base boundaries. Additional field work was performed to locate an abandoned Base water supply well (BW7) and to test the integrity of a segment of the industrial waste line adjacent to closed-down water supply wells.

This chapter describes the procedures and methodology used in field activities. Included are discussions on (1) the drilling program including Stage I and Stage II activities; (2) pump and slug tests; (3) sampling procedures; (4) locating Base production well 7; and (5) investigating the industrial waste line near Building 251.

DRILLING PROGRAM

The drilling program at McClellan AFB was implemented in two successive stages. A total of 48 monitoring wells were installed during this two-phased program. The Stage I wells were installed to identify the first and second water-bearing sands, to determine the direction of groundwater flow, and to identify potential groundwater contamination from past Base disposal practices. The location and depth of these Stage I monitoring wells were determined on the basis of existing hydrogeological information for the Base (primarily well logs from previously installed monitoring and water supply wells) and location of past disposal and storage areas on the Base. Some of the sites were "clustered" on the basis of their proximity to each other, and Stage I

monitoring wells were then installed downgradient from specific site clusters, which were designated Area A, Area B, Area C, and Area D. The Stage II drilling program was designed based on the analytical results obtained for the Stage I groundwater samples. The Stage I program identified a shallow groundwater table containing volatile organic compounds and deeper aquifers containing primarily small amounts of pesticides and herbicides. The Stage II program was subsequently designed to further delineate the extent and source(s) of contamination within the shallow water-bearing zone. The locations of all Stage I and Stage II monitoring wells and designated site clusters are shown on Figure 3.1. Specific well completion designs and geologic logs for each well are included in Appendix D.

Stage I Drilling Program

A total of 30 wells were installed during the first stage of the Phase II field program. Fourteen multiple-completion wells, each comprising both a shallow (S) well and a deeper (D) well, were installed into the first and second water-bearing zones (MW16S,D through MW29S,D). Two single-completion wells penetrating only the shallow zone (MW30 and MW31) were installed in the center of the Base to assist in determination of groundwater flow direction. The designs of the single and multiple-completion wells are shown schematically on Figures 3.2 and 3.3.

The Stage I well locations were selected to determine:

- * Depth to and thickness of the first water-bearing zone
- Depth to the second water-bearing zone
- Groundwater flow direction (MW30; MW31)
- Groundwater gradient
- ° Continuity between water-bearing zones at depth
- Background contaminant levels (MW28S,D)
- * Vertical extent of possible groundwater contamination
- * Constituent migration into the groundwater from
 - Area A (MW24S,D; MW25S,D; MW26S,D; MW27S,D)
 - Area B (MW23S,D)
 - Area C (MW20S,D; MW21S,D; MW22S,D)
 - Area D (MW19S,D)

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F16 3.1 MW485 MW 35S MW475 ● MW21S,D MW20S,D MW33S MW195, D ©MW34S MW22S, D ● **●**MW37S MW445 3 **●** MW45S MW18S,D ₩25S,D ● MW 31 MW 398 MW26S,D **● MW3**0 MW295,D _MW 275,D 28S,D • MW49S MW50S



LEGEND

MW16S,D

Location and Number of Multiple-Completion Monitoring Well

MW 31

Location and Number of Single-Completion Monitoring Well

MW 175,D

MWIES,D

LOCATION OF STAGE I AND STAGE II MONITORING WELLS McCLELLAN AFB, CA

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⊕MW38D

PAW34s MW36S

MW19S,D

MW37S

MW18S,D

MW 31

MW30

MW295,D

MW49S

MW50S

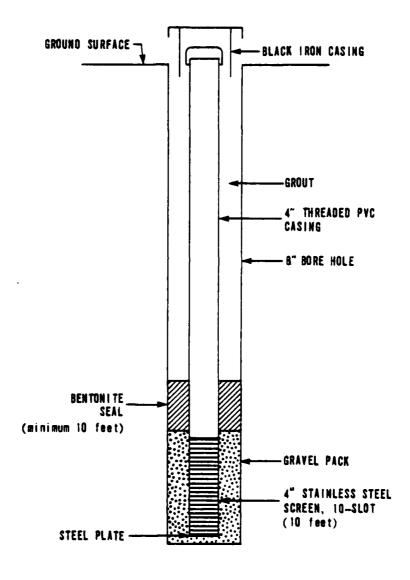
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TYPICAL WELL DESIGN SINGLE-COMPLETION MONITORING WELL McCLELLAN AFB, CA

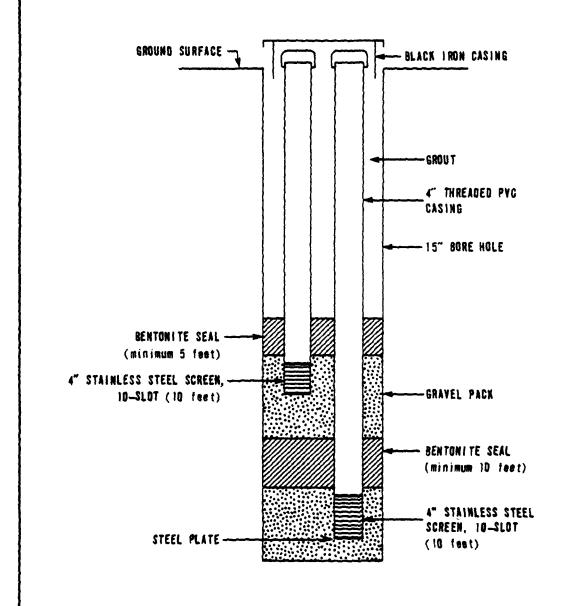


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NOT TO SCALE

ENGINEERING-SCIENCE

TYPICAL WELL DESIGN MULTIPLE-COMPLETION MONITORING WELL McCLELLAN AFB, CA



3-5

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- Sites 45 and 46 (MW18S,D; MW17S,D)
- Migration of groundwater contaminants onto the Base from off-base sources (MW16S,D)
- Migration of groundwater constituents off-base

The drilling methods employed consisted of hollow-stem augering and rotary wash. Drilling at each well was initiated with an 8-inch auger pilot hole for identification of the first water-bearing materials and for collection of undisturbed split-spoon soil samples for geological classification. Each auger hole was subsequently enlarged to 15 inches in diameter and extended in depth to the next water-bearing sands with a rotary-wash drill using fresh water with inorganic gel added as drilling fluid. The wells were installed and developed according to the specifications outlined in the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) Minimum Requirements for Well Drilling Operations. Stage I well installation was initiated in March 1982, but had to be interrupted due to unfavorable weather conditions; the remaining Stage I wells were installed in June 1982.

Stage II Drilling Program

Based on analytical and hydrogeological results obtained during the Stage I field program, a total of 18 monitoring wells, 17 shallow and one deep, were installed in Stage II. All Stage II wells (MW33 through MW50) were completed in the same manner as the single-completion Stage I wells (see Figure 3.2).

The well location network for Stage II was developed to identify more clearly specific groundwater contamination sources and source areas within site clusters that had shown downgradient groundwater contamination during Stage I. In addition, Stage II wells were installed along the southern and northern Base boundaries to ascertain aquifer characteristics along the downgradient boundary and to identify the magnitude of potential off-base constituent migration.

Although constituents were generally confined to the shallow water-bearing zone according to the Stage I results, two deeper wells were proposed for the Stage II program. Because Area D had shown the highest concentrations of priority pollutants in the shallow sands on

the Base, a well was installed downgradient from Area D in the deeper sands (MW38D) to ascertain potential vertical migration of constituents as well as possible off-base migration of contaminated groundwater in the second water-bearing zone. A deep well (32D) was also proposed immediately upgradient from Stage I wells 20S,D. Monitoring well 20S had shown the presence of aliphatics (grease and oil); groundwater analysis also detected the presence of aliphatic material in MW20D. This material may have been carried into the deeper well during initial well construction. Prior to implementation of the Stage II drilling program, well 20D was pumped and resampled to determine if the initial presence of aliphatics in the groundwater could have been due to cross-Analytical results of the second sampling revealed no contamination. aliphatics present; therefore deep well 32D was not installed upgradient from MW20D for identification of a potential source area. shallow wells were installed upgradient and downgradient of MW20S to locate a source for the aliphatics observed in that well.

The Stage II wells were installed to identify:

- Off-base constituent migration and aquifer characteristics along
 Base boundaries (MW38D, 36S, 35S, 48S, 47S, 43S, 42S)
- Background constituent concentration in shallow water-bearing sands and groundwater flow direction (MW50S)
- Contamination sources in Area A

Site 38: MW40S

Site 25: MW39S

Site 34: MW46S

Contamination sources in Area B
 Site 36: MW41S

• Contamination sources in Area C

Subarea C-1: MW34S, 44S, 45S, 33S

Subarea C-2: MW36S, 37S

* Contamination from Area D

Deeper sands: MW38D

The wells were installed using a rotary-wash drilling method. Pilot augering holes were not drilled in this stage since the Stage I

drilling program provided general information as to the probable depth of water-bearing materials. Figure 3.4 shows photographs of the drilling operation during installation of monitoring well 38D in the north-western part of the Base. The drilling fluid used was fresh water with no additives; the clays encountered at depth during drilling provided enough fluid viscosity to carry the bore cuttings to the ground surface. Wells were completed with locked iron casings above the ground. Four wooden posts were emplaced surrounding the wells in areas where the posts would not interfere with Base flight operations; in areas where conflicts existed, a concrete pad was installed around the iron casing. Figure 3.5 shows monitoring wells 27 and 25 at completion with posts and a concrete pad, respectively.

In addition to monitoring well installation during Stage II, two piezometers were completed adjacent to MW44S (see Figure 3.1); the piezometers were used for pump tests in conjunction with MW44S, as described in the following section.

PUMP AND SLUG TESTS

Pump and slug tests were conducted to evaluate the transmissibility of water-bearing sands and lateral and vertical continuity between each sands zone. One pump test (MW44S) and three slug tests (MW24S) were performed; the locations of these wells were indicated on Figure 3.1. Sample data sheets for recording field information are included in Appendix P. Field equipment used for these tests is listed in Appendix Q.

Pump Test

Based on pumping experience during earlier sampling events, well 44S was selected as the pumping well for the pump test. This well was capable of producing water continuously while being pumped at about 0.5 gpm; most other shallow wells ran dry when pumped and therefore would not sustain constant flow during a pump test. Two piezometers (44S-A and 44S-B) were installed at distances of 20 and 40 feet downgradient of the pumping well to monitor water level drawdown and recovery during pumping of MW44S.

DRILLING OPERATIONS McCLELLAN AFB, CA



PHOTO A
Geologist collecting sample of cuttings contained in drilling fluid at
MW38D for preparation of geologic log



PHOTO B Rotary-wash drill rig and water tank at MW38D

Photos Courtesy of USAF

COMPLETED MONITORING WELLS McCLELLAN AFB, CA

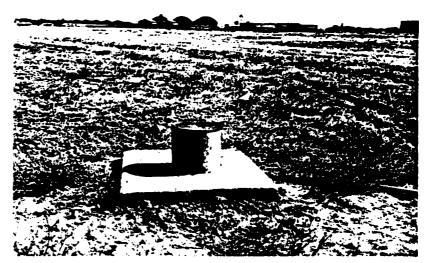


PHOTO A Monitoring Well 25S,D with locked iron casing and concrete pad completed within clear zone



Monitoring Well 27S,D with locked iron casing and wooden posts

Initial water levels were recorded for the pumping well and piezometers. The pump was then lowered into the pumping well (44S) and a second water level measurement was taken for this well; this water level was higher than the initial reading as a result of water displaced by the pump. At the specified time, the pump was activated and a series of water level readings were taken on the pumping well. Readings were obtained at 15-second intervals for the first two minutes, after which measurements were gradually reduced to once every 5 or 10 minutes, for a total pumping time of 220 minutes.

Simultaneously, flow rates were monitored for the pumping well. Flow rates were measured initially every 10 minutes until a constant rate was maintained, followed by readings every 30 minutes.

Water levels in the piezometers were monitored every 10 minutes during drawdown of the pumping well throughout the duration of the test. Final water level measurements were taken for the pumping well and piezometers just prior to stopping the pump.

When the pump was turned off, recovery measurements were taken on the pumping well. Readings were taken every 15 seconds during the first 2 minutes and then at increasingly longer intervals before reducing measurements to once every 5 or 10 minutes for the duration of the test. Water level measurements were taken until no further change in water level was detected. Water levels in piezometers were monitored once during recovery of the pumping well. No further readings were necessary because drawdown of both piezometers during pumping was minimal (less than 0.03 foot). At the end of the test, the pump was removed from the pumping well and one final water level reading was taken to determine the water level without pump displacement.

Slug Tests

Since only MW44S was productive enough for the performance of pump tests, a slug test was conducted on MW24S to obtain information on aquifer characteristics along the Base boundary. In the absence of pump tests, slug tests provide general order-of-magnitude data on permeabilities and transmissibilities of aquifers. Slug tests are often used when an aquifer shows low productivity and low permeability. A slug test

consists of releasing a known volume of water into a well casing and measuring the rate at which the water level returns to its original position.

Three replicate tests were performed on the well, two the first day and one during the second day. Fifty gallons of water were released into the well during the first test and 100 gallons were used for each of the other two tests. Each test was performed by filling a 55-gallon drum with water, elevating it above the well, and releasing the water into the casing at a specified time. Initial water levels were measured prior to each test. Immediately after all water was released into the well, water level measurements began. Readings were taken at 15-second intervals during the first 10 minutes of each test, followed by subsequent measurements at increasingly longer intervals. Each replicate slug test was conducted for three hours before it was completed.

SAMPLING PROCEDURES

Field sampling of wells for groundwater required careful sampling techniques to avoid sample cross-contamination and still obtain a representative sample. The step-by-step sampling protocol is included in Appendix P, along with field data sheets and the method used for calculating well casing volume for monitoring well purging and sampling.

Numerous decisions are required in the field to determine the method of sampling. A decision flow chart providing alternatives and solutions for use during sampling is shown in Figure 3.6.

Pumping and Sampling

Prior to sampling a well, the static water level was measured using an electronic water level meter (M-scope) calibrated at 10-foot intervals. This device is pictured in Figure 3.7. A steel measuring tape was then used to record water levels to within 1/10 inch.

Pumping was the preferred method for sampling. Approximately three casing volumes of water were removed from a pumpable well prior to sampling from the Teflon tubing. This preliminary pumping served to purge the well of standing water in the casing, replacing it with groundwater from surrounding water-bearing sands. Pumping also flushed the previous

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FIELD AND SAMPLING EQUIPMENT



PHOTO A
Electronic water level meter (M-scope) used to
measure static water level prior to sampling

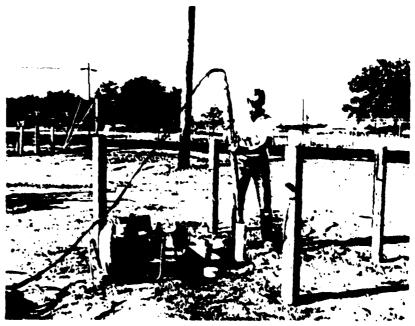


PHOTO B Submersible well pump used for pumping and sampling wells

sampling water from the pump and outlet tube (see Figure 3.7). Sampling from the Teflon tube eliminated potential cross-contamination between samples and/or from the tube itself. During pumping, the wells frequently ran dry prior to removal of three casing volumes of water. Allowing the well to recharge at least once prior to sampling insured collection of a representative groundwater sample from the aquifer. If too little water remained in the well to sample with the pump, samplers constructed of glass and Teflon were used.

Bailing and Sampling

Wells were bailed prior to sampling whenever the pump was not used, promoting thorough well water mixing and some groundwater recharge. A minimum of one well casing volume was removed from each well prior to sampling. Groundwater samples were obtained using a single sampler or a pair of samplers tied together in series. This "double sampler" is shown in Figure 3.8. Samplers were constructed of glass and Teflon to prevent the introduction of contaminants from sampler components. Glass and Teflon also minimized adsorption of groundwater constituents to the surfaces of the sampler.

Wells containing significant amounts of sand or silt caused the sampler to leak when being extracted from the well. The Teflon ball at the base of the sampler would not "seat" properly due to the silt, allowing sample water to escape. For these wells, an all-Teflon sampler which filled from the top was used instead. However, use of this type of sampler required that at least one gallon of water be in the well in order for the sampler to be filled from its top. Another disadvantage was that the actual sample volumes collected with the Teflon sampler were small. Schematic drawings of the glass/Teflon and the all-Teflon samplers are included in Appendix Q.

A glass funnel facilitated the transfer of sample water from samplers to sample containers (see Figure 3.8). The glass funnel minimized surface adsorption of groundwater constituents that could otherwise occur with a plastic (polyethylene) funnel.

After sampling, the samplers, bailer, and funnel were thoroughly cleaned and washed. Deionized/distilled water was used for the first

FIELD AND SAMPLING EQUIPMENT

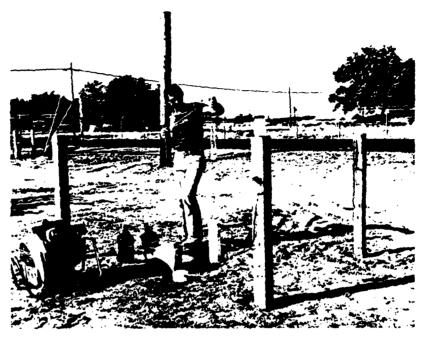


PHOTO A
Double sampler consisting of two glass and
Teflon samplers linked in series

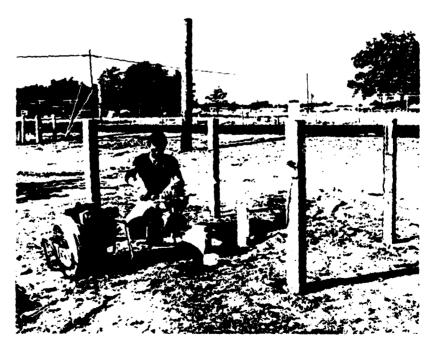


PHOTO B
Transfer of sample from glass and Tetion
samplers to sample containers using glass funnel

rinse, followed by a reagent grade acetone rinse to remove any organic constituents adsorbed to the equipment surfaces. A final triple rinse with deionized/distilled water removed the acetone.

Sample Containers and Types of Samples

Several types of samples were obtained from each well, requiring individual treatment and preservation. Containers were specially prepared in the laboratory for given analyses prior to transport into the During sampling, all containers were filled completely with sample water and capped. Volatile organic analysis (VOA) bottles were filled directly from either the Teflon tube of the pump or samplers. After filling and capping, these bottles were inverted and checked for air bubbles. If any were present, a second sample was obtained. Samples for trace metals were obtained in glass containers and preserved with ultra-pure nitric acid. Samples for cyanide, collected in a 1-liter polyethylene bottle, were immediately preserved by the addition of sodium hydroxide. All samples were tightly capped, placed in a thermal chest containing ice, and transported to the laboratory for further pretreatment and analysis. Laboratories utilized during the study were California Analytical Laboratories of Sacramento, California, and the ES Laboratory at Berkeley.

SPECIFIC CONDUCTANCE/TEMPERATURE TESTING

Seven wells were tested in the field for specific conductance and temperature. These were Base monitoring wells MW4, MW6, and MW7, and Stage I monitoring wells MW19S, MW19D, MW26S, and MW26D. Specific conductance measurements indicate the presence and magnitude of dissolved ions (e.g., salts) within the groundwater. Groundwater that is moving at a slow rate through an aquifer assumes some of the chemical characteristics of the aquifer material; thus, water in a less permeable aquifer generally has a higher specific conductance than water in a more permeable aquifer. Readings for specific conductance (measured in µmho) and temperature were taken in each well at approximate 10-foot intervals to determine whether stratification was evident within each well and whether detectable differences could be noted between the

shallow and deeper aquifers. Data for these wells are provided in Chapter 4, Results of Field Program.

LOCATING BASE PRODUCTION WELL 7

Part of the Stage I field program included establishing the location of Base production well 7, which was closed about 1956 due to reported contamination by cresylic acid. This was necessary since it was thought that well 7 could be a conduit for water to travel from near the surface down to lower production aquifers. Abandonment of the well in past years left no clue on the surface as to its location. A search of Base utility records snowed the approximate location to be near the west side of Building 475 in an underground well house. The buried well building was located with a magnetic flux indicator (Schonstedt GA-52 Magnetic Locator), and the tops of walls at the four corners of the building were potholed by hand.

The inside of the building was excavated and the well head was located in the building basement. The well building was approximately 10 by 20 feet in size and 12 feet deep. The well casing was extended by a 12-inch steel casing to facilitate future site identification. The extension of the well is shown as photograph A on Figure 3.9.

The concrete-encased well head was found to have been fitted with a non-watertight, fabricated steel cap. During excavation, a substantial amount of excess water from the fill material drained into the well. A weighted line lowered into the well met refusal at a depth of 80 feet. One of the gravel feed pipes to the 12-inch casing was found to have been disturbed, while another opening was discovered about 2-1/2 feet from the top of the well head. This second opening was to the gravel pack, which was sealed by a 24-inch outer casing and concrete well head. Sampling for priority pollutants was not accomplished because of excavated material having entered the well. The disturbed feed pipe was welded closed.

Air Force records did not indicate actions taken, if any, for abandonment of BW7. The well could have been backfilled, grouted, or left unused. In order to obtain a representative water sample, a drilling program was developed to clean out the well. Prior to cleaning out the

SITE RESTORATION AFTER LOCATION OF BASE PRODUCTION WELL 7

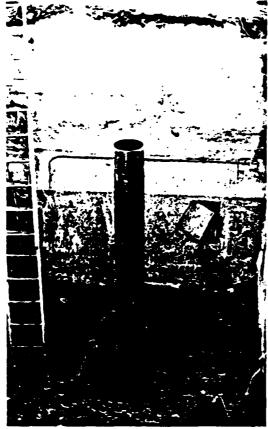


PHOTO A Extension of well casing



РНОТО В Backfill of excavation by Air Force



PHOTO C Extended well head Photos Courtesy of USAF

well, a 3-foot long, 12-inch diameter steel casing extension was welded onto the extension previously attached to the located well. The excavated area surrounding the well was backfilled by the Air Force to allow a drill rig to approach the casing for clean-out. This is shown as photograph B on Figure 3.9. A watertight cap was installed on the 24-inch casing and a supplemental lockable steel cap was fabricated and installed. The completed well head is shown as photograph C on Figure 3.9.

The well log from the time of installation (probably 1943) shows that the well consisted of a 12-inch steel casing with a double casing in the upper 50 feet. A diagram showing well construction of BW7 is presented on Figure 3.10. The annulus between the two casings is shown as being grouted, and the well was gravel packed for its entire depth of 398 feet. Perforations in the well casing begin at about 170 feet and extend to the bottom of the well.

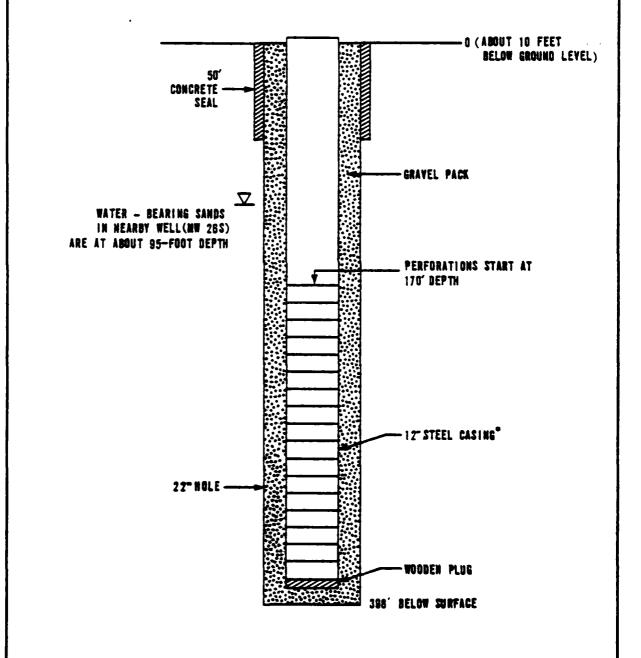
Rotary-wash drilling was employed for clean-out of the well using an 8-inch drill bit and fresh water as a drilling fluid. During drilling, the well appeared clear to a depth of 60 feet from the ground surface. At this depth, hard material was encountered and the cuttings showed a mixture of coarse sand and small amounts of clay with some wood chips. At 80 feet, the drill bit met refusal; the 8-inch drill bit was changed to a 4-inch bit, but the drilling still encountered refusal. At this time, drilling was aborted; the refusal could have been caused by either a crooked casing or concrete having been poured into the well for closure.

Subsequent interviews with Base personnel in the Water Department revealed that the well casing was possibly grouted in the late 1960's or early 1970's (Cunningham, 1982). This would seem probable in light of the refusal during drilling at a depth of 80 feet.

INDUSTRIAL WASTE LINE SURVEY NEAR BUILDING 251

An investigation of the industrial waste collection system in the vicinity of Building 251 was performed in January 1982. The purpose of this investigation was to determine if the industrial waste line was a possible source of constituents that necessitated closure of two Base

WELL CONSTRUCTION DIAGRAM BASE PRODUCTION WELL 7 McCLELLAN AFB, CA



*THE ORIGINAL WELL LOS INDICATES BOUDLE CASING (7) 3-21

NOT TO SCALE

production wells in the immediate vicinity. The system includes a 6-inch PVC force main between manhole 33 and the pump station at Building 243B, an abandoned 4-inch force main between manhole 33 and Building 243G, and 18-inch RCP gravity lines between manholes 32 and 33A and between manholes 32 and 33. Figure 3.11 shows the location of these facilities.

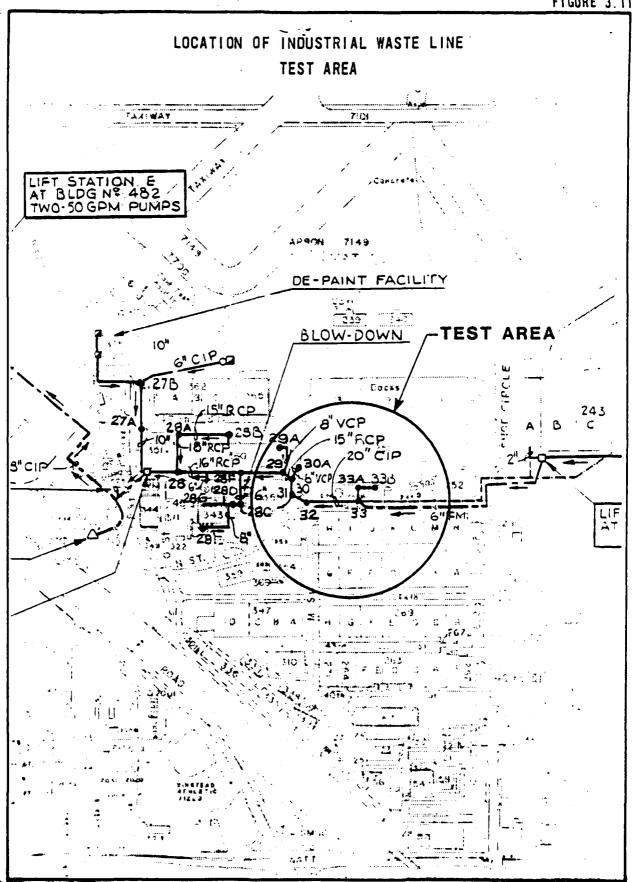
The integrity of these lines was evaluated through low-pressure air testing in accordance with ASTM C 828-78 and in conformance with CAL/OSHA safety orders and ES Industrial Sewer Entry Procedures. Individuals entering manholes wore complete life support systems. The photographs on Figure 3.12 show two people donning safety equipment and making final preparations just prior to manhole entry. Appendix R contains a listing of safety equipment and low-pressure air test equipment as well as the sewer entry procedures.

The 6-inch force main was plugged and a pressure of 4 psi (gage) was applied. This pressure held for an appropriate length of time, constituting a successful test. The pressure was subsequently boosted to 9 psi, which again held steady.

Testing of the 18-inch RCP gravity line was performed between the vapor traps at manhole 32 and manhole 33A. A maximum pressure of only 2 psi was obtained. Similarly, only 1 psi was attainable in the section between manholes 32 and 33.

In order to isolate areas of potentially high leakage in the 18-inch RCP gravity line, an attempt was made to test the line in overlapping 25-foot lengths. The first section tested held a maximum pressure of only 3 psi. Malfunction of one of the test plugs forced cancellation of further testing.

Visual inspection of the 18-inch RCP gravity line, at least 38 years old, showed it to be in reasonably good condition. However, the joints probably are the flush-bell-and-spigot-with-mortar type, which have a high potential for leakage compared to more modern rubber ring joints. The old joints could be a possible source of exfiltration throughout the 18-inch gravity sewer.



INDUSTRIAL WASTE LINE INSPECTION



PHOTO A

Donning life support system



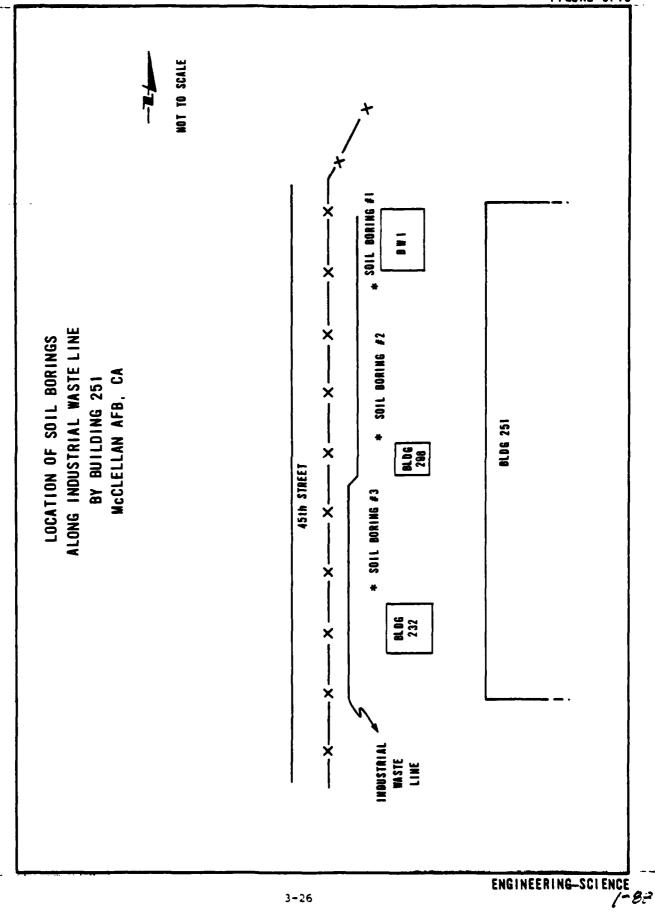
PHOTO B Preparing for manhole entry

Photos Courtesy of USAF

A drilling program was developed to obtain soil samples along the industrial waste line alignment. Analyses of the samples for GC/MS organics and trace metals were performed to identify potential soil contamination from the waste line if exfiltration had occurred in the past. Soil borings were completed at three locations along the waste line as shown in Figure 3.13. Two of the borings were located along the 18-inch diameter gravity portion of the line, while the third was along the 6-inch diameter force main. The waste line slopes from north to south from a depth of 8 feet by BW2 to 10 feet by BW1.

The three soil borings were completed with an 8-inch hollow-stem auger at a 30-degree slant from the vertical. Slant drilling allowed soil sampling to be performed directly beneath the waste line. The holes were drilled to a depth of 20 feet, and samples were collected at depths of 15 feet and 20 feet with a 1-1/2-inch split-spoon sampler. Following each sampling event, the spoon was rinsed in acetone and deionized water. The samples were collected in solvent-washed glass bottles and VOA bottles, then refrigerated and transported to the laboratory for analysis.

While drilling soil boring 2, the soil from the auger smelled of fuel; this was not noticed at the other soil boring locations.



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SECTION 4
RESULTS OF FIELD PROGRAM

CHAPTER 4

RESULTS OF FIELD PROGRAM

During the field program, the effects of past waste management practices on groundwater were investigated. This chapter discusses and evaluates the results of those investigations. Included are sections on analytical data, the hydrogeologic regime, field testing, and problem descriptions. The section on analytical data presents the results from laboratory analyses of groundwater samples from Base production wells, Base monitoring wells, Stage I wells, and Stage II wells in addition to discussions of data related to potential source areas and selected sites monitored during the Phase II field program. Also included are discussions of the industrial waste line survey near Building 251, as well as laboratory results for soil samples collected The section pertaining to the hydrogeologic beneath the waste line. regime contains discussions on the status of deeper aquifers and shallow sands as well as results from pump and slug tests. The field testing section covers establishing the location of Base production well 7, and logging specific conductance and temperature. A summary of the information presented in this chapter is provided in the final section on problem definition.

ANALYTICAL DATA

Groundwater samples were obtained from Base production wells, Base monitoring wells, and monitoring wells installed during Stages I and II of the field program. Specific constituents for analysis were selected based on materials used and waste products generated and disposed at McClellan AFB. Analyses performed included EPA priority organic pollutants (volatile organic compounds, acid and base/neutral compounds, pesticides/ herbicides, and polychlorinated biphenyls), trace metals, and

cyanide. Selected wells were also analyzed for cresylic acid and aliphatic material (grease and oil). Historical groundwater information and concurrent analytical results formed the rationale for these analyses. This section describes the analytical results obtained for all the wells on the Base, discusses analyses of soil samples collected near Building 251 beneath the industrial waste line, and summarizes the results of the waste line survey.

Records of sampling events for Base production wells, Base monitoring wells, and Stage I and II monitoring wells are contained in Appendices F, G, and H. Laboratory results for the constituents for which the groundwater and soil samples were analyzed are presented in Appendices J through N. Analytical procedures employed are described in Appendix S.

Base Production Wells

Analytical results for those organic compounds identified above detection limits in the groundwater samples from Base production wells are presented in Table 4.1. No other constituents tested were found in samples from any of the production wells.

The only wells that showed the presence of volatile priority pollutants during sampling in December 1981 were BW1 and BW2; these wells have since been closed. Though the two wells are located but a few hundred yards apart, the trichloroethylene (TCE) concentrations observed vary within two orders of magnitude (1,500 ppb and 10 ppb, respectively). Although no formal federal or state standard has been established for TCE in drinking water, the State of California Department of Bealth Services has utilized 5.0 ppb as an "action level". The concentrations of TCE detected in Base production wells during Stage I sampling events are presented on Figure 4.1.

Detectable concentrations of three other volatile organic compounds (VOC) were also found in samples from Base production wells 1 and 2. These compounds were chloroform (24 ppb), 1,2-trans-dichloroethylene (23 ppb), and 1,1-dichloroethylene (175 ppb). Chloroform is a natural byproduct of chlorine disinfection, and is used as a solvent for oils, rubber, alkaloids, and resins. 1,1-Dichloroethylene is an intermediate

TABLE 4.1

BASE PRODUCTION WELLS
ORGANIC COMPOUNDS IDENTIFIED IN GROUNDWATER SAMPLES
MCCLELIAN AFB, CALIFORNIA
(concentrations in ppb)

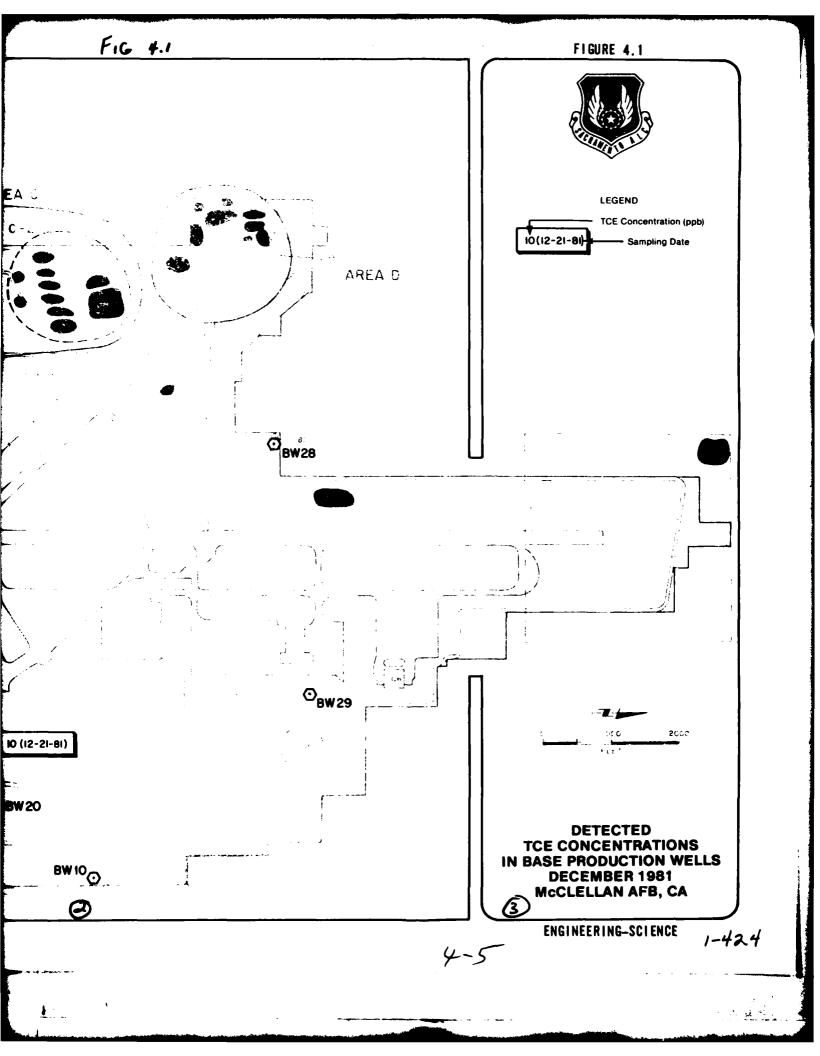
Compound				#e11	Number	and Bampli	ng Dates			
		BW1		BW2		976	Ē	=	•	H12
	12-21-01	12-21-81 1-11-82	12-21-0	1-11-02	12-21-0	11 1-11-02	12-21-01 1-11-62 12-21-61 1-11-02 12-21-61	1-11-02	12-21-01 1-1	1-11-62
Voletilee										
1, 1, 1-trichloroethene	2	•	000	1	2	1	2	1	욮	•
chlorofors	24	1	₽	•	皇	1	9	•	2	•
1, 1-dichloroethylene	2	1	175	1	9	1	2	•	2	•
1,2-trans-dichloroethylene	23	•	2	1	욡	•	2	•	9	•
trichloroethylene	1,500	•	2	1	2	•	9	•	g	•
Acid Compounds										
phenol	•	2	1	ę	r	ð	1	9	•	2
Pesticides/Herbicides										
alpha-BHC	ı	9	•	0.12	•	9.36	•	9	ı	0.003
beta-8MC	ſ	皇	ť	ð	•	2	1	9	٠	웆
game-BHC (lindene)	ľ	2	1	90.0	•	9	ı	90.0	•	9
000	•	2	•	9	•	9	ı	0.07	1	윷
I mellen I	•	2	•	0.03	ı	2	•	60.0	1	9
endosulfan sulfate	ı	2	•	0.17	•	2	1	2	•	9
heptachlor	t	Q .	٠	9.05	•	9	I	2	•	2
2,4-D	1	0.04	•	0.0	•	9.06	•	0.03	•	0.03
2,4,5-	•	2	1	9. 18	•	0.01	•	0.004	١	9.08
Polychiotinated Biphenyle										
Aroclor 1254	•	9	1	9	,	£	1	2	•	60.0 %

TABLE 4.1 (Continued)

<u>.</u>....

Compound				1	Number	Well Number and Sampling Dates	ng Dates			
	BW13	13		BW17		Btv 18	35	BW28		BW29
	12-21-81 1-11-82	1-11-82	12-21-81	12-21-81 1-11-62	12-21-8	12-21-61 1-11-82	12-21-81 1-11-82	1-11-62	12-21-01	12-21-81 1-11-82
Volatiles										
1, 1, 1-trichloroethane	2	•	9	•	ş	•	2		Š	•
chloroform	2	•	Q	•	2	•	9	•	ş	•
1, 1-dichloroethylene	9	ı	2	•	2	,	욯	•	2	•
1,2-trans-dichloroethylene	2	1	皇	•	2	,	₽	ı	Q	1
trichloroethylene	9	•	9	•	9	,	9	•	2	1
Acid Compounds										
phenol	•	410	•	ğ	ı	Ş	1	ş	•	9
Pesticides/Nerbicides										
alpha-BMC	•	0.004	•	ě	ı	ě	1	9	•	9
beta-BHC	•	ş	•	皇	1	0.10	ı	2	•	•
gamma-BHC (lindene)	•	2	•	Q.	•	Q		2	ı	9
000	•	2	•	9	1	2	,	Q.	•	2
endosulfan I	•	ð	•	0.27	1	ş		윷	,	ş
endosulfan sulfate	1	욮	•	ş	1	Ş		ş	•	2
heptachlor	1	Ž	1	0.04	•	Ş	ı	Ž	•	2
2,4-D	•	900.0	•	9	•	2	,	0.008	ι	0.01
2,4,5-7	•	900.0	1	9	1	0.003	ı	0.002	•	0.003
Pulychlorinated Biphenyle aroclor 1254	•	0°.09	•	60.0	1	60.09		0.24	ı	60.09

MD = not detected (-) = sample was not analyzed for this compound a See Appendix J for a complete list of analyzes performed.



for vinylidene polymers. A concentration of 0.24 ppb was detected for aroclor (a polychlorinated biphenyl) in a groundwater sample collected in January 1982 from BW28.

Various concentrations of pesticides and herbicides were detected in all Base production wells. These compounds included 2,4-D and 2,4,5-T, the herbicides detected most frequently throughout the Base. The highest concentration of 2,4-D detected was 0.06 ppb at BW8. This value is three orders of magnitude lower than the California Drinking Water Standard of 100 ppb (California Administrative Code, Title 22). No current standard exists for 2,4,5-T. All the herbicides and pesticides found either are currently used or have been used extensively in the past for Sacramento Valley agriculture.

Trace metal analyses of the Base production wells showed concentrations of all the metals except zinc to be at or below limits of detection. These detection limits are equivalent to the California Drinking Water Standards for each metal except zinc, mercury, copper, and lead. The highest zinc concentration detected in any Base production well was 0.097 mg/l at BW11. California Secondary Drinking Water Standards reflect maximum zinc levels of 5.0 mg/l, more than 50 times greater than the concentration in BW11. Results of the trace metal analyses for all Base production wells are presented on Table 4.2.

Base-Installed Monitoring Wells

A complete EPA priority pollutant scan was performed for all Base monitoring wells. The organic compounds found above detection limits in these monitoring wells are identified in Table 4.3. Constituents which were not detected in any of the Base monitoring wells are not listed in the table.

Trichloroethylene was detected in groundwater samples from every Base monitoring well except MW4. Excluding MW10 through MW15, the TCE concentrations ranged between 0.54 ppb at MW3 to 296 ppb at MW8. The detected TCE concentrations in Base monitoring wells are shown on Figure 4.2. The base/neutral compound bis(2-ethylhexyl)phthalate was identified in all of the groundwater samples at a maximum concentration of 100 ppb; this compound is commonly used in vacuum pumps and vacuum chambers.

TABLE 4.2

BASE PRODUCTION WELLS
TRACE METALS IDENTIFIED IN GROUNDWATER SAMPLES
MCCLELLAN AFB, CALIFORNIA
(concentrations in mg/l)

Metal				X []	Well Number and Sampling Date	Sampling D	2				•
	1-11-82	BW2 1-11-82	BW8 1-11-62	1-11-82	BW12 1-11-82	BW13 1-11-82	1-11-82	BW18 1-11-82	BW26 1-11-62	1-11-82	Ca DWS ^b (mg/1)
Antimony (Sb)	<0.00\$	<0.00\$	<0.005	¢0.005	<0.00	<0.005	<0.00\$	<0.005	<0.005	<0.005	N.S.C
Arsenic (As)	<0.05	<0.0>	<0.05	<0.0>	<0.05	<0.0>	<0.05	<0.05	<0.05	<0.05	0.05
Cadmium (Cd)	(0.0)	(0.01	(0.01	10.03	(0.0)	(0.01	(0.01	(0.0)	(0.01	(0.01	0.01
Chromium (Cr)	0.055	<0.05	<0.0>	<0.05	<0.0>	<0.0>	<0.05	<0.0>	<0.05	<0.05	0.05
Copper (Cu)	<0.05	<0.05	<0.05	<0.05	دن.05	<0.05	<0.05	<0.05	<0.05	<0.0>	1.0
Lead (Pb)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.01	(0.0)	(0.01	(0.0)	0.05
Mercury (Hg)	(0.001	(0.00)	(0.001	0.001	(0.001	(0.001	(0.001	(0.00)	(0.001	(0.001	0.002
Nickel (Ni)	<0.05	<0.0>	<0.05	<0.05	<0.0>	<0.05	<0.05	<0.05	<0.05	<0.05	N.S.C
Selenium (Se)	(0.01	(0.01	(0.01	(0.01	(0.0)	(0.01	(0.01	(0.0)	(0.0)	(0.0)	0.01
Silver (Aq)	<0.05	<0.05	<0.0>	<0.05	<0.0>	<0.05	<0.05	<0.05	<0.05	<0.0>	0.05
Sinc (Zn)	0.028	0.02	<0.02	0.097	<0.02	<0.02	<0.02	<0.02	0.048	<0.02	5.0

a See Appandix 3 for a complete list of analyses performed.

b Ca DWS - California Drinking Water Standard (California Domestic Water Quality and Monitoring Regulations, California Department of Health Services, 1977). Values listed for copper and zinc are Secondary Drinking Water Standards.

C M.S. - Wo standard has been established for drinking water.

TABLE 4.3

BASE MONITORING WELLS
ORGANIC COMPOUNDS IDENTIFIED IN GROUNDWATER SAMPLES
MCCLELLAN AFB, CALIFORNIA
(CONCENTRATIONS IN ppb)

Compound						Well Mus	Well Number and Sampling Dates	Depitng D	ates				
		444	4	1446	9		7.994			8748		674	
	12-22-81	3-31-82	3-31-82 4-28-82	12-22-81 3-30-82	3-30-62	12-22-01	3-17-82 ^b	3-29-82	12-22-81	3-31-82	12-22-81	3-31-82 ^C	4-28-82
VOIS TIES	,	Q	•	•	Q	•	2	QN	•	410	1	2	2
carbon tetrachloride	•	2	•	ı	2	ı	2	2	•	2	•	2	52
chlorobenzene	1	S	•	1	2	•	9	웊	•	Q	1	QN	2
chloroform	١	2	1	1	QN	ı	9	Q	1	¢10	1	9	20
1, 1-dichloroethane	•	Q	•	•	Q	•	QN	QN	1	QN	1	2	2
1, 2-dichloroethane	•	ş	•	•	Q	•	2	Q	1	QN	1	2	Q
1, 1-dichloroethylene	•	2	•	•	Q	1	QN	QN	•	9	•	9	Q
1,2-trans-dichlororthylene	•	9	•	1	QN	•	50	76	ı	01 >	•	Q	ON
ethyl benzene	•	2	•	•	ş	•	9	QN	1	01 >	•	Q	QN
methylene chloride	•	Q	1	•	QN	1	Q	QN	•	2	•	9	Ä
tetrachloroethylene	1	2	1	•	Q	•	ON	Q	•	Q	1	2	Q Z
toluene	•	QN.	١	•	QN	•	đ	QN.	•	QN.	1	Q	QN
1, 1, 1-trichloroethane	•	Q	•	•	QN	•	æ	QN	•	9	1	Q	2
trichloroethylene	0.54	2	1	911	24	14.4	30	59	296	61	4.03	ğ	225
trichlorof luoromethane	•	QN	,	,	Q.	,	QN	9	ı	QN	•	QX	2
vinyl chloride	•	Q	1	1	9	•	Q	2	1	2	1	웆	9
Acid Compounds													
2, 4-dimethylphenol	•	2	1	ı	2	•	9	2	•	2	•	ž	Q
phenol	•	9	•	t	2	•	Q	2	•	00	•	2	2
Base/Neutral Compounds													
bis (2-ethylhexyl)phthalate	•	5	•	1	16	•	12	13	1	100	•	17	Q
butyl benzyl phthalate	•	Q	ı	4	Q	1	9	Q	1	¢10	•	윺	2
1, 2-dichlorobenzene	•	Q	•	ı	Q.	•	Q.	QN	•	9	,	2	2
I, 3-dichlorobenzene	•	QN	•	•	QN QN	•	QX	N	1	MD	1	Q	Q¥
1, 4-dichlorobenzene	,	Q	1	•	2	•	2	Q	1	2	1	Q	Q
naphthalene	1	2	•	•	Ω N	•	욮	Q	•	Q	•	2	Q Q
1,2,4-trichlorobenzene	•	9		•	2	•	Q	Q	•	Q	•	2	Q
Pesticides/Herbicides													
Aldrin	•	ı	G	•	Ž	1	0.26	1.03	•	QX	•	0.15	₹
a I pha - BHC	•	1	ž	ı	Q	•	Q	QN	1	Q¥	1	90.0	Q X
gamma-BIK (lindane)	•	•	2.76	1	9	ı	2	Ç	•	0.005	1	0.12	91.0
heptachlor	•	•	QN	1	0. 10	•	2	0.88	1	0.0	1	2	2
heptachlor epoxide	•	•	Q	1	Q	•	2	Î	•	9	١	90.0	Q
2,4-D	•	1	0.377	1	, 0.02	1	Q	0.03	•	Q	•	N Q	2
2,4,5-T	•	ı	Î	1	0.006	•	0.005	Q	t	0.008	•	0.003	0.001
2,4,5-TP (Silvex)	1	•	90.0	1	Ę	•	æ	Q	1	2	•	2	2

TABLE 4.3 (Continued)

12-22-81 1-90-28 12-22-81 1-90-28 1-92-81 1-	Compound					5	Taller I	S Post				
12-22-61 1-30-82 12-22-61 3-30-82 6-16-92 12-22-61 4-29-82 6-16-82 13-22-91 1-30-42		3	01		=			2000	and hates			
No.		12-22-81	3-30-82	12-22-81	3-30-82	8-18-82	12-22-01	4-29-82	8-18-82	12-22-81	3-30-82	8-18-82
No.												
1	Volatiles											
No.		1	2	ı	000	Q	1	QN.	3	,	9	Í
No.	carbon tetrachloride	ı	2	•	2	2	2	3	, ,	9	1	ì
## 1.00	chlorobenzene	1	2		2	ON.	1	S	3	1	1	ì
tchylene - 19 - 170 250 - 180 100 100 100 100 100 100 100 100 100	chloroform	•	Ŷ	•	0	910	•	1	2	•	2 9	2
## 17 17 18 18 18 18 18 18	1, 1-dichloroethane	1	19	•	1 20	250		ì	2 2	•	⊋ ;	2
tribylene - 500 - 19,300 63,000 - 4,200 2,500 - 1,100	1, 2-dich loroe thane	'	1.1	١	9	2	l	2 9	2 :	•	2	2
1	1, 1-dichloroethylene	,	200	•	19 300	000	1	2 5		ı	₹ :	2
1	1, 2-trans-dichloroethylene	•		,	9		ı	7, 200	2,500	•	. 100	780
1		,	2	1	2	9	•	2	2	1	98	٠
1,000 1,00	methylene chitoride		2	•	2	2	1	2	2	•	2	2
No.	totatoh basetalan		2	ı	3, 200	QN	•	2	QN N	•	1,000	2
No.		•	Q	ı	<u>•</u>	Ŷ	•	20	18	•	50	917
No.	and the second s	·	ş	•	80	2	•	2	₹	1	2	£
113 140 10.4 2,160 5,000 3,730 930 160 8,920 1,470	1, 1, 1 - tt ich lordethane	•	2	ι	4,300	12,000	1	2,700	520	•	902	9
No.	trichloroethylene	×313	140	10.4	2, 100	5,000	3,730	930	091	8.920	1.470	3 6
## The control of the	trichlotor Juoromethane	•	QN.	•	¥	2	•	¥C	7	'	Ñ	î
## ND	vinyi chloride	1	Q	•	20	Q	•	2	N.		3	2 (
The late of the la	Acid Compounds										3	2
### ### ### ### ### ### ### ### ### ##	2, 4-dimethylphenol	•	QN	,	2	1		á	i			
### ### ### ### ### ### ### ### ### ##	phenol	1	Q.	•	2	Î	. (ì	2 2	•	2	2
### 14	Base (Neutra) Communda				1		,	ì	ì	·	₹	2
### 15	4	,	:		;	;						
The state of the s	buty benzy shekalata	·	2 (ı	Ξ	Q	1	OM	QN	•	9	Ş
Fig. 13	1.2-dichloropenen	,	2 ;	ı	2	2	•	₹	q	•	2	QN
Fig. 1. ND		•	?	•	000	2	•	Q	QN.	٠	410	2
ND 10 10 10 10 10 10 10 1		,	2	•	Ş	410	•	ş	QN	٠	ž	2
FOR THE PROPERTY OF THE PROPER		1	Ž	1	Ş	10	1	Ç	2	,	Q	Ŷ
- 1,80 - 10 ND - 12 ND - 12 ND - 10 ND - 12 ND - 10 ND - 12 ND		•	ĝ	,	01	52	•	3	Q.	•	ž	Î
1,80		ı	Ê	•	Î	•	•	Ŷ	12	1	₹	ŝ
1.80	Pesticides/Herbicides											
MD	Aldrin	•	1.80	1	2	1	•	2	1	,	9	
M	a Ipha - BIK	•	Ş	1	₹	•	•	2	,		Î	•
M	qama-BiK:	•	ê	,	Î	•	•	â			1	ı
M	heptachlor	1	Ŝ	•	Q	1	1	ì	ı	ı	₹ :	ı
. ND . ND . ND . ND ND	heptachlor epoxide	•	3	1	•		ı	ì	1	•	È	•
P (S1 lvex) - (N)	2,4-D	•	Ì	1	È		1	Î	•	1	2	ı
P (S1 Lvex) - ND - N	2.4.5-1	ħ	2	1	Ì :	ı	,	Î	ı	1	t	ı
TON	2.4.5-TP (C) Line (1)	•	Ê	•	£	ı	t	0.004	,	1	600.0	•
	ABAT TO LILE OF THE		Î	٢	Î	•	•	Ŷ	•	•	£	•

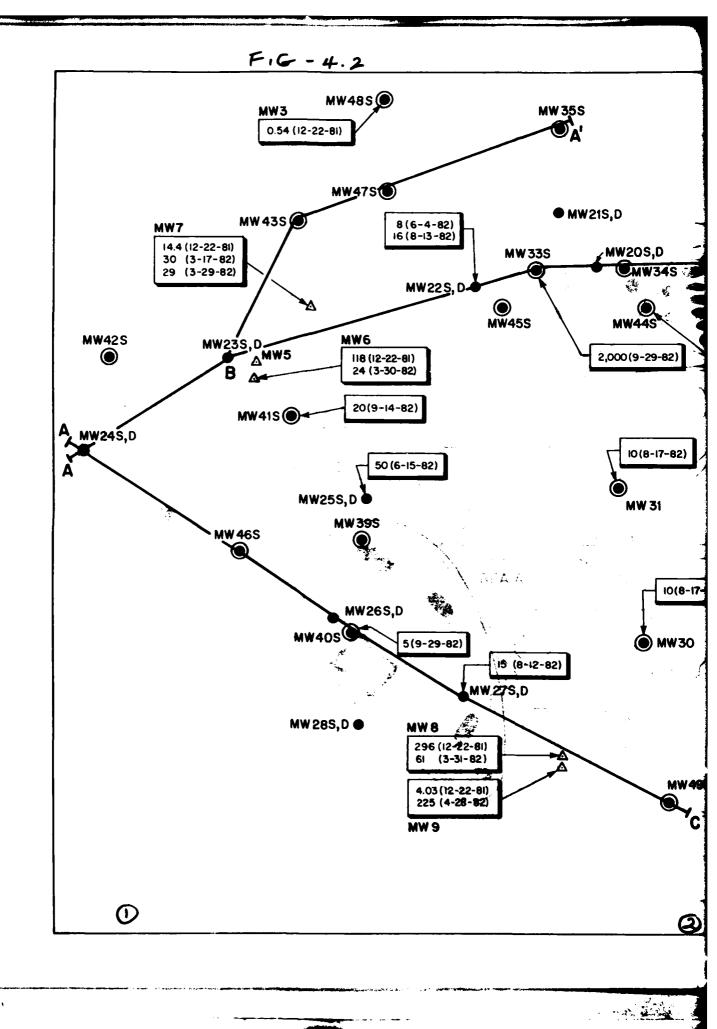
TABLE 4.3 (Continued)

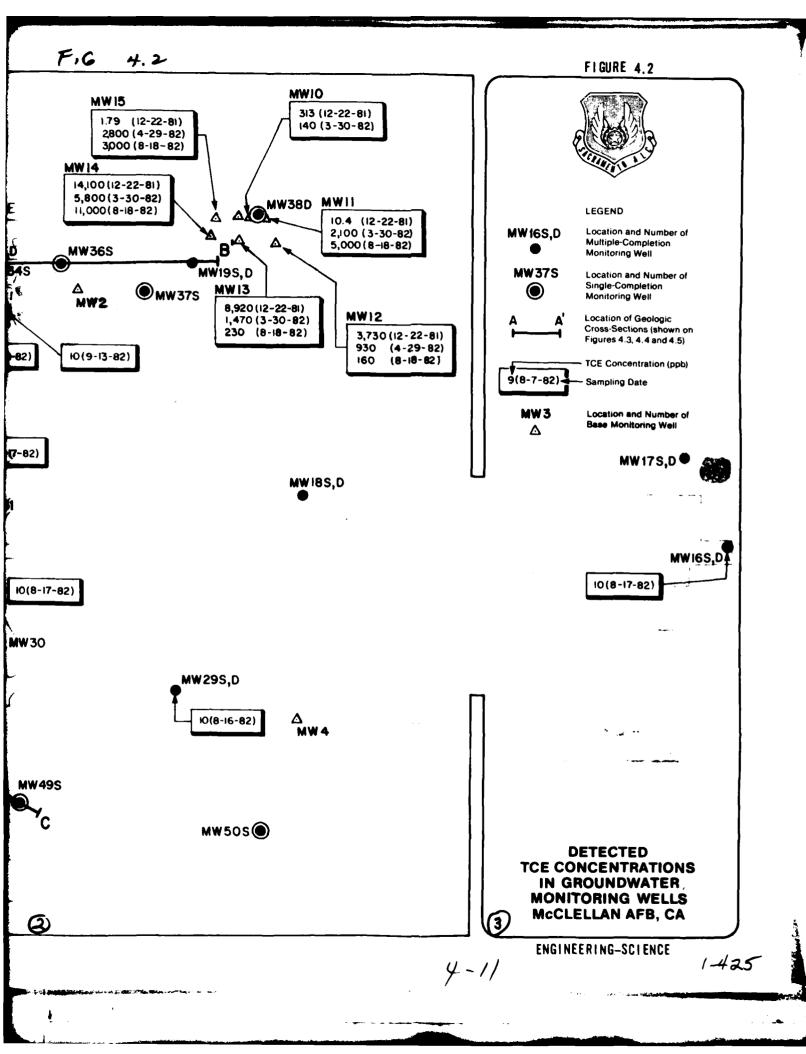
Compound		200	Well Number and Sampling Dates	ING SAMPLIN	d Dares	
		7.75			25.25	
	12-22-81	3-30-82	8-18-82	12-22-81	4-29-82	8-18-82
Voletiles						
henzena	,	900	2	ı	089	2
carbon tetrachloride	•	2	Q	•	2	7
chlorobenzene	ı	410	QN	1	7	Ê
chloroform	•	120	010	•	20	2
1, 1 -dichloroethane	ı	011	901	,	225	200
1,2-dichloroethane	1	2	Ç		2	2
1, 1-dichloroethylene	1	4,600	17,000	•	5,980	9,600
1,2-trans-dichloroethylene	•	1 30	200	ı	135	011
ethyl benzene	1	2	2	,	2	2
methylene chloride	1	3,000	Q	•	2,000	윺
tetrachloroethylene	•	QN	2	•	Q	2
toluene	•	20	GN.	•	£	3
1,1,1-trichloroethane	1	8, 700	2, 300	•	2,200	2,500
trichloroethylene	14, 100	5, 800	11,000	1.79	2,800	3,000
trichlorof luoromethane	•	2	2	•	2	2
vinyl chloride	•	52	QN	•	2	¢10
Actd Compounds						
2,4-dimethylphenol	•	61	3	,	ş	Î
phenol	•	010	4 00	ı	₹	Ž
Base/Meutral Compounds						
his (2-ethylhexyl)phthalate	1	=	2	ı	2	ì
butyl benzyl phthalate	•	2	Î	•	2	Î
1, 2-dichlorobenzene	1	22	9	1	2	20
1, 3-dichlorobenzene	•	01 <i>></i>	28	1	3	•
1,4-dichlorobenzene	•	01 0	9	1	Î	12
naphthalene	,	2	¢10	1	2	2
1, 2, 4-trichlorobenzene	•	2	9	1	ŝ	Ş
Pesticides/Herbicides						
Aldrin	•	6.97	•	•	2	1
a lpha-84tC	ι	2	•	1	Q	•
qama-BHC	•	2	,	•	Ŷ	•
heptachlor	•	Q	,	,	Ç	•
heptachlor epoxide	,	Ñ	1	,	SE	1
2,4-D	•	1	,	i	0.05	•
2, 4, 5-T	į	0.005	1	•	Î	•
1 A 6 60 101 harm		Î	,		92.0	•

MD = not detected

a See Appendix K for a complete list of analyses performed.

b This well contained large quantities of silt; the well was sampled on 17 March 1982, and the sample analyzed. On 24 March 1982, this well as well as the existing menitoring wells were cleaned out for silt, and an additional nample was taken on 29 March 1982. c When this well was sampled on 31 March 1982, the water level was measured at a depth of 9 feet helow the ground surface. The well cap was missing, and rainwater had entered the well.





A number of pesticides/herbicides were identified, the prevalent ones being 2,4-D and 2,4,5-T.

The wells in the sludge pit area (MW10 through MW15) all showed high concentrations of volatiles, particularly TCE, methylene chloride, 1,1-dichloroethylene, and 1,1,1-trichloroethane, which are common degreasing agents and/or associated impurities. Monitoring wells 11, 14, and 15 appear to contain the greatest numbers and concentrations of constituents. It should be noted that MW14 appears to have been installed directly within a former sludge/oil disposal site; this may be the reason for the high concentrations of groundwater constituents detected in this well.

Several trace metals were detected in the Base monitoring wells, particularly chromium, lead, mercury, nickel, and zinc. Data for metals identified above detection limits in these wells are contained in Table 4.4. Arsenic and silver were the only two metals not detected in any of the Base monitoring wells. Generally, except for zinc, mercury, copper, and lead, analytic limits of detection are equivalent to the established California Drinking Water Standards. (No state standards have been established for antimony or nickel in drinking water.) Any other values above detection limits therefore exceed drinking water standards. The wells containing most of the metals were MW4, MW8, and MW10, where antimony, cadmium, chromium, lead, mercury, nickel, selenium, and zinc were detected.

Stage I Monitoring Wells

Several shallow (S) Stage I monitoring wells revealed the presence of organic constituents. Analytical results for priority pollutants found above detection limits in the Stage I shallow wells are presented in Table 4.5. The detection of compounds was not consistent over successive samplings. Constituents present from the first sampling were often absent during the second sampling. Conversely, compounds initially absent were detected during the second sampling. Groundwater from MW20S, located along the western border of the Base, showed the greatest number of constituents present. Benzene (45 ppb), ethyl benzene (220 ppb), and toluene (440 ppb) were the volatiles identified above detection limits in MW20S; base/neutral compounds detected in water from that

TABLE 4.4

TRACE METALS IDENTIFIED IN GROUNDWATER SAMPLES MCCLELLAN APB, CALIFORNIA (concentrations in mg/l) BASE MONITORING WELLS

						Well Num	Well Number and Sampling Dates	ampling D	etes					
Heta]	I	24.0	•	q.₩	97	. ₹	-6886	01981		HH12	MM13	PB41	5199	Ca DWSd
	4-28-82 3-30-82		3-17-82 3-29-82	3-29-62	ا بدا	3-31-82 4-28-82			100	3-30-82		3-30-82	3-30-62	(1/6=)
Antimony (Sb)	0.016	0.016 <0.005	<0.005 <0.005	<0.005	900.0	<0.005 <0.005	<0.005	0.007	<0.00\$	<0.00	(0.005	<0.00\$	900.0	E.S.
Arsenic (As)	<0.05	<0.05	<0.0>	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Cadmium (Cd)	0.014	٥٠.0١	(0.01	<0.01	0.013	(0.0)	(0.01	0.012	(0.0)	(0.0)	0.01	(0.0)	0.012	0.01
Chromium (Cr)	90.0	<0.05	0.21	0.09	0.90	<0.05	<0.05	0.12	0.07	<0.05	<0.05	0.09	<0.05	0.05
Copper (Cu)	<0.05	<0.05	<0.0>	<0.0>	<0.05	<0.0>	0.12	<0.05	<0.05	<0.05	<0.05	<0.0>	(0.05	1.0
Lead (Pb)	(0.0)	0.109	0.081	0.023	96.0	0.29	(0.01	0.03	0.093	(0.01	0.022	0.057	(0.01	0.05
Mercury (Hg)	0.0007	0.0005	0.0005	0.0005 0.0005	900000	0.0006	0.0006 <0.0005	0.0010	0.0021	<0.0005	0.0010	0.0011	0.0011 <0.0005	0.002
Nickel (Ni)	0.01	90.0	0.10	0.05	0.08	<0.05	<0.05	0.10	<0.05	<0.05	<0.05	0.09	0.07	S.S.
Selentum (Se)	0.016	(0.01	(0.0)	(0.01	0.027	(0.01	(0.01	(0.01	0.049	(0.01	(0.01	(0.0)	(0.0)	0.01
Silver (Ag)	<0.05	<0.05	<0.0>	<0.05	<0.05	<0.0>	<0.05	<0.05	<0.05	<0.05	<0.05	<0.0>	<0.05	0.05
Zinc (Zr)	0.10	0.028	0.21	0.15	96.0	0.15	0.05	0.073	0.036	0.01	0.03	0.05	<0.05	5.0

a See Appendix K for a complete list of analyses performed.

b This well contained large quantities of silt; the well was sampled on 17 March 1982, and the sample analyzed. On 24 March 1982, this well as the existing monitoring wells were cleaned out for silt, and an additional sample was taken on 29 March 1982.

C. When this well was sampled on 31 March 1982, the water level was measured at a depth of 9 feet below the ground surface. The well cap was missing, and rainwater had entered the well.

Brassing, and rainwater had entered the well.

G. DAS - California Drinking Water Standard (California Domestic Water Quality and Monitoring Regulations, California Department of Health Services, 1977). Values listed for copper and zinc are Secondary Drinking Water Standards.

TABLE 4.5

STAGE I SHALLOW WELLS
ORGANIC COMPOUNDS IDENTIFIED IN GROUNDATER SAMPLES
MCCLELLAN AFB, CALIFORNIA
(concentrations in ppb)

					3	1 Number	Well Number and Sampling Dates	ng Dates				
		12		175		185	-	98	7	208		218
	6-16-82	2 6-17-82	6-16-62	8-17-82	6-15-82	8-16-82	4-28-82	8-16-82	5-25-82	9-11-82	6-15-82	8-13-82
Volatiles	;	!	;	;	•	•	;	•	,	!	į	į
	2 9	2 9	2 9	2	2 9	2 5	2 2	2	9 9	2	2 9	2
	2	2 9	2 9	2	9	2	9	1	1	2 1	}	1
1 1 4 4 4 4 1 Crossbullens	2	2 5	2 2	2	2	2	1	2	9	1	1	9
	2 2	2 9	2 9	1	2 2	2 2	1	2 9	2 2	2	1	ì
	2 9	€ €	2 9	2 9	2 9	2 2	2 9	2 9	2 2	2 4	9	2 2
methylene chioride	€	2	₹ 1	2	2	2	2	2	2	2	3	2
tetrachloroethylene	2	2	2	2	2	2	2	¢10	2	2	2	2
toluene	9	유	윺	2	9	2	2	ş	40	S	2	뎙
1, 2-trans-dichloroethylene	2	Q	Q	Q	2	Q	9	Q	2	2	2	2
trichloroethylene	ş	10	9	2	Q	9	2	QN	9	ě	윺	GN
4												
ACTO COMPOSITOR		;		;		,	;	,	!	į		;
pentach lorophenol	2	2	9	2	£	٠	<u>a</u>	•	<u>a</u> ₹	2	2	2
Bank (Manthes) Constants												
anthracene	2	Ş	9	2	2	2	9	QN	2	220	9	QN
benzo(a)anthracene	2	£	Q	Q.	Ş	2	2	9	9	2	2	2
bis (2-ethylhexyl)phthalate	A	2	2	22	Q	•	QN	70	2	2	230	2
chrysene	2	2	2	Q	Q	2	2	ş	9	2	2	Q
di-n-butyl phthalate	Q	2	Q	2	9	2	욮	2	2	Q.	ş	Q X
fluoranthene	2	Q	QN	QX	QN	Q	2	Q.	2	2	뎙	3
fluorene	Q	9	£	Q	Q	Q	QX	ş	ğ	90	Q	2
naphthalene	웆	Ģ	QN	Q	Q	Q	Q	Q	Q	90	2	9
phenanthrene	Q	Q	Q	QN QN	Ş	Q	2	Q	Q	Q.	2	9
pyrene	욮	Q.	Q	2	웊	¥	₹	9	₹	2	£	2
Pesticides/Herbicides												
Aldrin	0.503	Q	0.112	2	0.052	QN	2	9	QN	2	0.049	2
a 1 pha - BHC	QN	0.024	£	2	QN	0.032	₽	2	2	2	Ş	₹
beta-8MC	0.142	0.00	9	ã	Q	Q	Q¥	æ	Q.	2	Ş	0.048
de I ta-BHC	£	0.025	£	2	2	2	£	2	2	2	Ş	2
gamma-BHC (lindane)	Ş	0.020	Q	Q	Q.	0.036	0.047	Ş	2	2	2	2
dieldrin	Ş	Q	ş	Q	Q	Q	0.20	Ş	2	Q	Q.	9
endosulfan sulfate	Q	(0.03	2	Q	Q	S	9	Ş	2		0.011	2
heptachlor	2	0.015	Q	Ç	9	Q.		0.056	Ş	2	2	2
heptachlor epoxide	Ç	Q	Q	Q.	2	0.027	2	2	2		2	0.007
2,4-D	0.058	2	0.114	2	0.138	2	₹	ş	2	0.13	0.122	2
2, 4, 5-T	0.020	2	0.031	Q.	ş	2	<u>Q</u>		0.008	3	0.087	2
2,4,5-TP (Silvex)	0.094	ĝ	Q	Q	£	2	₹	욮	2	2	£	윤

TABLE 4.5 (Continued)

Compounds					4	Well Number and Sampling Dates	nd Sampli	ng Dates				
•		228		238		245		258		265		
	6-4-82	8-13-82	4-28-6	4-28-82 8-13-82	4-28-8	4-28-82 8-12-82	6-15-8	6-15-82 8-12-82	6-16-8	6-16-82 8-11-82	6-16-82	8-12-82
Volatiles												
benzene	2	2	욡	2	2	9	웊	2	2	2	2	2
carbon tetrachloride	2	2	웆	ş	웆	9	쥧	2	2	2	2	0;°
chloroform	£	Ş	윭	9	3	9	Q	윾	9	Q	욮	01
1,1-dichloroethylene	£	2	웆	2	물	2	2	웆	2	2	윭	2
ethyl benzene	윷	9	2	2	2	9	9	2	Q	2	2	2
methylene chloride	2	9	2	2	윺	9	2	2	€	2	9	2
tetrachloroethylene	2	2	₹	Q	£	9	9	9	2	2	2	2
toluene	2	2	2	3	₹	2	2	ş	2	2	9	Q.
1, 2-trans-dichloroethylene	욡	9	물	QM	윭	Q	9	Q	2	9	9	410
trichloroethylene	6 0	91	2	Q	2	욮	20	2	2	2	욧	15
Actd Compounds												
pentachlorophenol	2	51	¥	9	2	260	Q	2	2	Q	Q	120
Base/Neutral Compounds												
anthracene	엹	QN	윺	Q.	2	Q	Q	410	2	ã	욡	9
benzo(a)anthracene	2	Q	皇	Q	뎙	Q	9	010	쿭	2	2	2
bis(2-ethylhexyl)phthalate	9	9	윺	Q	쿭	2	2	Q	2	2	2	2
chrysene	Ş	2	2	윺	2	9	9	01 >	2	£	2	2
di-n-butyl phthalate	2	6	2	9	욮	9	2	2	2	2	2	Q
fluoranthene	2	9	ş	2	2	2	2	01	2	£	9	£
fluorene	Ş	9	9	Q	웊	2	2	2	웆	2	2	2
naphthalene	2	2	2	줱	욮	2	9	2	¥	9	Q	9
phenanthrene	2	2	£	Q	£	2	皇	010	£	2	Ş	2
pyrene	욮	9	욮	£	2	2	2	010	2	£	윺	Q.
Pesticides/Herbicides												
Aldrin	2	Q	2	Q	2	Q	Q	2	0.165	QN	4.95	9
a I pha -BHC	2	0.057	2	2	웆	2	₽	Q	£	0.035	₽	£
beta-BHC	2	2	2	Q	윺	2	2	2	2	0.077	Q.	2
de I ta-BHC	0.83	Q	ş	Q	2	Q	2	2	2	Q	2	2
gamma-BHC (lindene)	0.064	윷	2	0.034	2	Q	2	2	0.013	0.053	9	2
dieldrin	2	9	웆	윺	웆	Q	2	웊	ş	9	ş	2
endosulfan sulfate	Q	Q	2	2	욮	Q	2	2	욽	2	2	9
heptachlor	2	2	웆	Q	웆	2	0.32	2	£	ş	Ç	2
heptachlor epoxide	윷	Ş	윤	Q	2	Ç	ą	2	0.095	2	Ş	2
2,4-D	0.026	9	윷	9	£	욧	ş	2	0.003	2	2	2
2, 4, 5-T	0.003	Q.	윷	Q	2	0.027	Q	2	0.005	0.003	9	0.002
2,4,5-TP (Silvex)	0.031	9	2	Ş	ş	2	윷	2	0.004	2	£	2

TABLE 4.5 (Continued)

Compounds			3	Mumber	Mell Number and Sampling Dates	o Dates		
	265		7	296	308			318
	6-16-82	8-17-62	4-28-82	4-28-82 8-16-82	6-16-82 8-17-82	1-17-82	6-15-82	6-15-82 8-17-82
VOISTITUE	2	•	ş	2	ş	2	2	2
carbon tetrachloride	2 2	•	1	1	2	2	9	9
chloroforn	9	•	2	9	9	1	1	ş
1 1 -dichloroethelene	1	•	9	9	9	9	9	9
ethyl bengana	2	•	2	2	9	2	2	2
methylene chloride	QN	•	9	2	1,500	3	2	2
tetrachloroethylene	2	•	2	2	2	2	2	2
toluene .	2	•	2	9	9	웆	2	2
1,2-trans-dichloroethylens	9	•	æ	9	3	2	윷	2
trichloroethylene	9	•	£	0.	9	0	2	9
Acid Compounds	S	•	ş	2	ā	\$	3	Ç
	2		}	ì	}	}	ì	}
Base/Weutral Compounds	g	•	2	9	ş	2	2	2
benzo(a)anthracene	9	•	2	2	2	2	2	9
bis (2-ethylhexyl)phthalate	2	•	2	91	150	2	2	2
chrysene	QN	•	2	Q	2	2	2	2
di-n-butyl phthalate	Ş	•	윷	Q	2	2	2	2
fluoranthene	9	•	욡	9	2	2	2	Q
fluorene	9	•	Ž	2	£	줥	2	2
naphthalene	Q.	•	2	9	2	2	2	9
phenanthrene	윺	•	2	2	2	2	윺	Ş
Pyrene	Q	•	£	2	Q.	2	2	2
Pesticides/Herbicides								
Aldrin	0.61	•	Z	2	0.041	Q	2.53	2
alpha-BHC	QN	•	£	Q.	2	0.018	2	0.024
beta-8MC	2	•	2	2	0.001	9	2	2
delta-BHC	Q.	•	윷	2	2	2	2	9
gamma-BHC (lindane)	윺	•	2	1.54	2	2	2	0.0085
dieldrin	2	•	2	2	2	¥	웆	2
endosulfan sulfate	윤	•	윺	2	2	2	2	2
heptachlor	2	•	Q	2	2	£	윭	2
heptachlor epoxide	0.17	•	2	Q	2	2	2	0.011
2,4-D	0.014	•	2	2	0.063	윷	2	2
2, 4, 5-T	0.00	•	ş	Q	0.024	Q	Q.	0.003
2, 4, 5-TP (Silvex)	2	•	2	Q.	9	웊	2	Ş

ND = not detected a complete list of analyses performed.

1705

well were anthracene (220 ppb), fluorene (190 ppb), and naphthalene (190 ppb).

Additional constituents detected in the Stage I shallow wells were primarily trichloroethylene, pentachlorophenol, and bis(2-ethylhexyl)-phthalate. TCE data for the Stage I shallow wells are depicted on Figure 4.2. Other constituents (volatiles and base/neutral compounds) are near limits of detection, except methylene chloride in well 30S (1,500 ppb). A number of pesticides and herbicides were identified in most wells, predominately 2,4-D and 2,4,5-T. Pesticide/herbicide results for Stage I shallow wells are shown in Table 4.5.

Trace metal data for the Stage I shallow wells are shown on Table 4.6. Two of the wells (MW19S and MW29S) contained all of the metals analyzed, except silver. Well 23S showed detectable levels of all metals except cadmium and silver. Wells 19S and 23S border the western boundary of the Base adjacent to waste disposal sites. However, MW29S is more centrally located on the Base, without an apparent source for metals. Several other shallow wells contained metals, primarily antimony and mercury. Most of the metals identified above analytical detection limits exceed allowable California drinking water standards.

Those compounds showing concentrations above detection limits for the Stage I deep wells are presented in Table 4.7. None of the Stage I deep wells contained organic constituents above detection limits, except for herbicides/pesticides and one base/neutral compound. Bis(2-ethyl-hexyl)phthalate appears in MW18D and MW29D at concentrations of 12 and 9 ppb, respectively. The identified herbicides/ pesticides were similar to those detected previously in Base wells, primarily 2,4-D and 2,4,5-T.

Trace metals in the Stage I deep wells are given on Table 4.8. Trace metals in the Stage I deep wells were near or below limits of detection. Several wells contained minimal but detectable concentrations of cadmium and mercury, which exceed California drinking water standards established for these metals at 0.010 mg/l and 0.002 mg/l, respectively. Concentrations exceeding these standards were detected for cadmium in MW18D and MW27D, and for mercury in MW19D and MW28D. Well 22D contained an anomalous concentration of chromium (0.84 mg/l), while all other deep wells except MW25D showed less than detectable

TABLE A 6

STAGE I SHALLOW WELLS
TRACE METALS IDENTIFIED IN GROUNDMATER SAMPLES
MOCLELLAM AFB, CALIFORNIA
(concentrations in mg/l)

			Well No	Well Number and Sampling Date	mpling Date				
Hetel®	168	178	168	198	208 5-25-82	218	228	238	Ca DMS ^b (mg/1)
Antimony (Sb)	0.00	0.011	<0.00\$	0.06	0.026	(0.005	¢0.00\$	0.025	N.S.
Arsenic (As)	<0.05	<0.0>	<0.05	0.66	0.24	<0.05	<0.05	0.30	0.05
Cadmium (Cd)	(0.0)	(0.01	(0.01	0.045	0.03	(0.0)	0.03	<0.01	0.01
Chromium (Cr)	<0.05	<0.05	<0.05	4.17	<0.05	<0.05	<0.05	1.04	0.05
Copper (Cu)	<0.05	<0.05	<0.05	1.18	<0.05	<0.05	<0.05	0.33	0.1
Lead (Pb)	(0.0)	(0.01	(0.0)	0.08	(0.01	40.01	(0.0)	0.026	0.05
Mercury (Hq)	0.0027	0.0012	0.0016	0.0016	<0.0005	0.0014	<0.0005	0.0009	0.005
Mickel (NI)	<0.05	<0.05	<0.05	1.33	40.18	<0.05	40.1B	0.41	
Selenium (Se)	(0.01	(0.0)	(0.0)	0.355	0.074	0.0	(0.01	0.057	0.01
Silver (Ag)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.0>	0.05
Sinc (In)	<0.02	<0.02	<0.02	1.75	<0.02	<0.02	<0.02	1.4	5.0

TABLE 4.6 (Continued)

4-28-82 258 6-15-82 6-15-82 (-15-82 6-15-82 6-15-82 (-15-82 6-15-82 6-15-82 (-15-82 6-15-82 6-15-82 (-15-82 6-15-82 6-15-82 (-15-82 6-15-82 6-15-82 (-15-82 6-15-82 6-15-82 (-15-82 6-15-82 6-15-82 (-15-82 6-		م ا	l l	298 4-28-82 0.041 0.55 0.08	· ·	S	Ca DMSD (mg/1) N.S.C 0.05
0.006 (0.005 (0.05 (0.05 (0.01 (0.01 (0.05 (0.05 (0.05) (0.05)	S		(0.005 (0.05 (0.01	0.041	\$0.00\$ \$0.00\$	<0.00\$	N.S. C
(0.05 (0.05			<0.05 <0.01 <0.05	0.55	(0.0)	<0.0>	0.05
(0.0) (0.0)			(0.01	0.08	(0.0)		0.01
(0.05 (0.05			<0.05	0.24	•	٥٠.0١	
<0.05 <0.05 <0.01 <0.01					40.0 2	<0.05	0.05
(0.0)		60.03	.0.05	0.59	<0.0>	<0.0>	1.0
		(0.0)	(0.0)	0.022	(0.01	(0.01	0.05
Mercury (Hg) 0.0016 <0.0005 <0.0005	0005 <0.0005	6.00.0	<0.000\$	0.0021	0.0016	0.0017	0.002
Nickel (Ni) <0.05 <0.05 <0.05		<0.05	<0.05	2.13	<0.0>	0.0 5	S. 2
Selentum (Se) <0.01 <0.01 <0.01		(0.0)	10.0>	0.105	(0.01	(0.0)	0.01
Silver (Ag) <0.05 <0.05 <0.05		<0.05	<0.05	<0.05	<0.0>	<0.05	0.05
Zinc (Zn) 0.04 0.032 <0.02		د0.02	0.052	2.96	<0.02	<0.02	5.0

(-) = no sample (well dry)
a See Appendix L for a complete list of analyses performed.
b Ca DMS - California Drinking Water Standard (California Domestic Water Quality and Monitoring Regulations, California Department of Health Services, 1977). Values listed for copper and zinc are Secondary Drinking Water Standards.
c N.S. - No standard has been established for drinking water.

TABLE 4.7

STAGE I DEEP WELLS
ORGANIC COMPOUNDS IDENTIFIED IN GROUNDWATER SAMPLES
MCCLELLAN AFB, CALIFORNIA
(concentrations in ppb)

Compound					Well Num	Well Number and Sampling Dates	empling.	Dates						
•	-	3		٩	281	Q	-	961	30D	۵		210		22D
	6-16-82	2 8-17-82	6-15-82 8-17-82	8-17-82	6-15-82 8-16-82	8-16-62	4-28-82	4-28-82 8-16-82	4-28-82 8-11-82	8-11-82	6-15-82	6-15-82 8-13-82	4-28-8	4-28-82 8-13-82
1.1-dichloroethylene	Q	2	9	Q	9	2	2	2	2	Q	ğ	2	2	Q
1.2-trans-dichloroethylene	2	2	9	2	2	ş	2	2	ş	2	2	ą	2	2
1, 1, 1-trichloroethane	9	Q	9	2	Ç	QN	2	Q	Q	¢10	2	2	2	Q
trichloroethylene	9	01 >	2	Q	9	Q	2	9	윺	⊋	윺	2	욡	Q.
Acid Compounds	9	ş	2	Ş	â	2	ş	2	2	2	9	Q	Q	2
Topped	2	2	2		È	È	ì	2	2	Ì	}	}	}	•
Base/Neutral Compounds	ş	ş	Ş	Ş	9	9	3	2	2	9	2	9	Ş	2
bie(2-ethylberyl)ohthalate	2	2	9	2	2	17	2	9	2	2	2	2	2	2
1, 2, 4-trichlorobenzene	웊	皇	2	2	웊	2	2	010	全	¢10	Q	¢10	2	¢10
Dest to the Merky of the														
Aldrin	0.005	2	QN	Q	0.01	9	2	2	2	2	0.012	2	2	QN
a lpha - BHC	2	2	2	£	2	2	2	2	2	2	2	2	9	Q
beta-BHC	QN	ş	2	2	0.005	9	9	Q	2	2	2	Q	2	Q
delta-BHC	9	Ş	£	2	Ç	Q	₽	9	Q	2	웆	Q	2	0.0039
gamma-BHC (lindene)	2	Q¥	Ş	웆	Q	Q	2	Q	Q X	2	2	2	2	Q
3 00	ð	2	윷	Ö	2	Q		<0.006	₹	£	9	2	웆	2
endosulfan I	Q	9	9	2	9	Q	욡	Q	Q	ě	900.0	2	2	2
endrin	æ	Ş	£	₽	Q	Ð	웆	2	2	2	£	2	웆	Q
heptachlor	0.008	Q	Q	웆	Q	Q	2	Q	î	Q	윷	2	2	2
heptachlor epoxide	Q¥	SK	Q	QN	0.017	Q	Ş	<0.004	₹	£	₹	2	웆	Z
2,4-D	0.082	Q	0.099	2	0.122	9	0.008	Q	Q#	Ş	0.175	Q	2	Q.
2,4,5-T	0.037	Ş	0.032	Ş	0.022	Q	웆	₹	2	ş	0.044	(0.001	옾	2
2,4,5-TP (Silvex)	0.080	2	Q	Ş	Q	2	0.003	Q	2	2	0.45	2	2	Q

TABLE 4.7 (Continued)

Compound					Well	Well Number and Sampling Dates	Sampling	3 Dates						
		230		240		250		260		27D	1	28D		290
	4-28-82		4-28-8	4-28-82 8-12-82	6-15	6-15-82 8-12-82	- 1	4-28-82 8-11-82	4-28-8	4-28-82 8-12-82	.	6-16-82 8-17-82		4-28-82 8-16-82
Volatiles														
1, 1-dichloroethylene	2	Q.	2	ð	2	QN	2	QN	Q	QN	2	¢10	2	¢10
1,2-trans-dichloroethylene	₹	2	웆	QX	2	410	2	QN	₹	ş	£		웊	2
1, 1, 1-trichloroethane	윺	Q	2	ş	ž	QX	2	QN	2	2	웆	₽	2	2
trichloroethylene	€	Q	Q	2	Q.	610	2	Q¥	9	410	Q	2	2	2
Acid Compounds														
phenol	Q	9	9	Q	Q	Q	Q	01 >	Q	Q	9	QN	Q	Š
Base/Neutral Compounds														
anthracene	2	9	2	2	Q	QN	₽	QN	Q	2	2	Q	N	Q.
bis(2-ethylhexyl)phthalate	윭	2	웆	£	2	Q	2	욮	9	욮	2	2	2	6
1, 2, 4-trichlorobenzene	웆	00	2	01 0	2	01	9	0 0 0	2	610	Q	2	2	Q
Pesticides/Herbicides														
Aldrin	욮	Q	£	Q.	윷	Q	2	Q.	2	QN	0.145	9	2	Q
alpha-BHC	윺		윺	£	2	9	2	2	£	Ð	2	2	2	Q
beta-BHC	윷	9	웆	9	2	Q	Q	Q	웆	Q	0.027	2	2	Q
delta-BHC	£		욡	윷	£	2	Q	2	웆	2	2	Q	2	Q
gamea-BHC (lindane)	윷		0.00	2	9	Q	2	2	0.13	2	2	Q	0.82	0.0825
DOR	2		2	9	身	QN	Q	₽	웆	2	윺	*00.00	웆	Q
endosulfan 1	읖		2	2	2	2	2	Q	2	2	2	Q		Q
endrin	웆		£	2	웆	600.0>	Q	2	웆	2	2	2	£	Q
heptachlor	욮	Q	2	Q	2	QN	QN	QN	¥	Q	2	2	2	Q N
heptachlor epoxide	물		웆	9	윺	Q.	2	9	¥	2	2	*00.00	웆	Q
2,4-D	웆	Q	웆	Q	0.12	Q	Q	9	0.04	Q	0.246	Q	2	Q
2, 4, 5-T	웆	9	0.60	0.005	0.025	0.004	0.004	0.038	윷	0.003	0.022	(0.001	웆	2
2.4.5-TP (Silvex)	g	ž	2	2	2	Q	Q	2	2	QN	2	2	2	Q

MD = not detected a See Appendix L for a complete list of analyses performed.

TABLE 4.8

STACE I DEEP WELLS
THACE METALS IDENTIFIED IN GROUNDMATER SAMPLES
MCCLELIAN APB, CALIFORNIA
(concentrations in mg/l)

				We 1]	Well Number and Sampling Date	ampling Dat	9		•
	160	170	180	190	200	210	22D	230	Ca DWS
Metal	6-16-82	6-15-82	6-15-82	4-28-82	4-28-82	6-15-82	4-28-82	4-28-82	(mg/1)
Antimony (Sb)	<0.00\$	<0.005	<0.00\$	<0°00°	<0,005	<0.005	<0.00\$	<0.00\$	N.S.
Arsenic (As)	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	0.05
Cadmium (Cd)	(0.0)	(0.01	60.0	(0.0)	(0.0)	(0.01	(0.0)	(0.0)	0.01
Chromium (Cr)	<0.05	<0.05	<0.05	<0.0>	<0.05	<0.05	0.84	<0.05	0.05
Copper (Cu)	<0.05	<0.0>	<0.05	<0.0>	<0.05	<0.05	<0.05	<0.05	1.0
Lead (Pb)	(0.0)	(0.01	(0.01	(0.0)	(0.01	(0.0)	(0.0)	(0.0)	0.05
Mercury (Hq)	<0.000\$	6000.0	40.0014	0.013	<0.0005	<0.0005	<0.0005	0.001	0.003
Nickel (NI)	<0.05	<0.0>	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	.s. 5
Selentum (Se)	(0.0)	(0.01	(0.0)	(0.0)	(0.0)	(0.01	(0.0)	(0.01	0.01
Silver (Aq)	<0.05	<0.0>	<0.0>	<0.0>	<0.05	<0.05	<0.05	<0.05	0.05
21nc (2n)	<0.03	<0.02	<0.02	0.13	<0.05	<0.02	91.0	<0.05	5.0

TABLE 4.8 (Continued)

			Well Numb	Well Number and Sampling Date	ling Date		4
Meta]	24D 4-28-82	250 6-15-82	260	270 4-28-82	280	290	Ca DWS ^D (mg/l)
Antimony (Sb)	<0.005	<0.005	<0.005	0.005	<0.005	<0.005	S. S.
Arsenic (As)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Cadmium (Cd)	(0.0)	(0.01	(0.01	0.033	(0.0)	(0.01	0.01
Chromium (Cr)	<0.05	90.0	<0.05	<0.05	<0.05	<0.05	0.05
Copper (Cu)	<0.05	<0.05	<0.05	0.13	<0.05	<0.05	1.0
Lead (Pb)	(0.0)	(0.01	(0.01	(0.01	(0.01	(0.01	0.05
Mercury (Hg)	0.0008	<0.0005	•	<0.0005	0.0039	<0.0026	0.003
Nickel (N1)	<0.0>	<0.05	<0.05	<0.05	<0.0>	, 50.0 5	N.S.
Selenium (Se)	(0.0)	(0.0)	د0.01	(0.01	(0.0)	(0.01	0.01
Silver (Aq)	<0.0>	<0.05	<0,05	<0.05	<0.05	<0.05	0.05
Zinc (Zn)	0.14	0.024	0,05	0.32	0.14	0.07	5.0

(-) ** sample not analyzed for this metal a See Appendix L for a complete list of analyses performed. b Ca DMS - California Drinking Water Standard (California Domestic Water Quality and Monitoring Regulations, California Department of Health Services, 1977). Values listed for copper and zinc are Secondary Drinking Water Standards. c N.S. - No standard has been established for drinking water.

levels of chromium. The California drinking water standard for chromium is 0.05 mg/l. Zinc was present in over half the deep wells, although all concentrations were one order of magnitude lower than the zinc secondary drinking water standard of 5.0 mg/l.

Stage II Monitoring Wells

The groundwater samples from the Stage II monitoring wells were analyzed for all EPA priority organic pollutants. Analytical results for those organic compounds found above detection limits in Stage II wells are given in Table 4.9. Compounds listed are those present in one or more wells.

Four of the shallow (S) Stage II monitoring wells showed the presence of two base/neutral compounds. Bis(2-ethylhexyl)phthalate, a constituent commonly identified in the Stage I wells, was detected at concentrations of 68 ppb in MW33S and 54 ppb in MW36S, while wells 41S and 44S showed low levels of 1,2,4-trichlorobenzene (4 and 8 ppb re-These four wells (MW33S, MW36S, MW41S, and MW44S) also spectively). contained various volatile organic compounds, including trichloroethylene, chloroform, 1,2-trans-dichloroethylene, 1,1-dichloroethylene, and tetrachloroethylene. Two other shallow Stage II wells contained volatile compounds. Well 40S showed the presence of TCE at 5 ppb, and chloroform was detected at 5 ppb in MW46S. TCE data for all Stage II wells are presented on Figure 4.2. Most of the shallow Stage II wells contained herbicides and pesticides characteristically present in the Stage I wells.

One deep well, MW38D, was installed and sampled during the Stage II program. This well contained bis(2-ethylhexyl)phthalate (42 ppb) and numerous volatile compounds in addition to one pesticide (beta-BRC) above detection limits. Two compounds detected in MW38D which were not previously noted in the shallow wells were 1,1-dichloroethane (75 ppb) and 1,1,2-trichloroethane (5 ppb).

Trace metal data for Stage II monitoring wells are listed in Table 4.10. None of the Stage II shallow wells contained trace metals above limits of detection except for lead and zinc. Well 38D contained only zinc (0.09 mg/l) above detection limits. Zinc concentrations in all

TABLE 4.9

STAGE II WELLS
URGANIC COMPOUNDS IDENTIFIED IN GROUNMATER SAMPLES
MCCLELIAM APB, CALIFORNIA
(concentrations in ppb)

				Well Nu	Well Number and Sampling Date	ampling Da	at.		
Compound	33S 9-29-82	14S 9-28-82	358	368	37S 9-28-82	398 ^b	408	418	428
Volatiles									
chloroform	·c	•	•	2	£	2	9	웆	3
1,1-dichloroethane	2	•	•	2	9	9	2	9	욡
1,1-dichloroethylene	9	•	•	Ž	2	ş	2	\$	2
1,2-trans-dichloroethylene	30	•	•	2	9	9	2	01	Q
tetrachloroethylene	£	•	•	Ś	9	2	2	윷	2
1,1,1-trichloroethane	2	•		Q	£	2	9	₹	9
1,1,2-trichloroethane	Ş	•	•	2	웆	2	2	2	Q
trichloroethylene	2,000	•	•	2	2	2	s	07	2
Base/Neutral Compounds									
bis(2-ethylhexyl)phthalate	69	•	•	54	Z	2	3	2	2
di-n-butyl phthalate	2	•	•	Ģ	2	£	2	2	윷
1,2,4-trichlorobenzene	2	•	•	QN	9	2	2	•	2
septo idres/ septo trasd									
Aldrin	(0,003	•	•	(0,003	<0.003	•	(0.003	00.003	(0,003
a) pha -BHC	<0.005	•	•	<0.003	<0.003	•	<0.002	<0.002	<0.00
beta-BHC	c0,004	•	•	<0.00	*00.00	•	*00.00	40.00¢	*00.0 0
delta-BHC	0.066	•	•	0.052	0.121	•	0.048	40.00¢	0.051
qamma-BHC (lindane)	<0.003	•	•	0.015	<0.00	•	c0.00 2	<0.00	<0.00
chlordane	*0.0	•	•	¢0.0	*0.0 *	•	*0.0 *	¢0.04	*0.0 *
ODO (TDE)	<0.012	•	•	<0.012	<0.012	•	<0.012	<0.012	<0.012
. 300	40.006	•	•	900.0>	00.00	•	°0,006	*0.00	40.006
100	40.03	•	•	40.016	40.016	•	0.016	40.016	40.016
dieldrin	<0,006	•	•	900.0>	00.00	•	0.006	40.00	900°0
endosulfan I	<0.00	•	•	<00.00>	<0.00>	•	<0.00	<0.00	<0.00
endosulfan II	(0.0)	•	•	(0.0)	(0.0)	•	(0.0)	(0.01	.0.0
endosulfan sulfate	(0.03	•	•	<0.03	(0.03	•	<0.03	(0.03	(0.03
endrin	¢00°0>	•	•	<0°00	600.0>	•	600.00	600°0>	600.0 >
heptachlor	<0.002	•	•	<0.002	<0.00	•	<0.002	<0.003	<0.00
heptachlor epoxide	¢0.00¢	•	•	0.01	¢0.004	•	60.00	*00.0 >	*00.0
methoxychlor	<0.02	•	•	<0.02	<0.02	•	¢0.05	<0.02	<0.02
toxaphene	60.4 0	•	•	c0.40	<0.40	•	60.40	<0.40	00.4 0
2,4-D	0.134	•	•	0.56	<0.001	•	(0.001	(0.001	(0.00)
2,4,5-T	(0.001	•	•	(0.001	0.004	•	(0.001	(0.00)	(0.001
2,4,5-TP (Silvex)	<0.002	•	•	<0.002	<0.002	•	<0.002	<0.002	0.031

TABLE 4.9 (Continued)

	438	448	458	465	475	485	498	208	380
	9-14-82	9-13-82	9-14-82	9-29-82	9-29-82	9-15-82	9-29-82	9-14-82	9-27-82
VOIALI 168		!		1					
chlorotors	2	2	₹	s	2	•	2	•	2
1,1-dichloroethane	£	3	2	ì	₹	•	9	•	75
1,1-dichloroethylene	2	30	₽	Q.	€	•	2	•	200
1,2-trans-dichloroethylene	2	ą	2	2	2	•	2	•	80
tetrachloroethylene	2	2	Ş	2	Q	•	Q	•	2
1, 1, 1 - trichloroethane	Q	9	£	Q	9	•	2	•	\$5
1,1,2-trichloroethane	£	2	2	2	2	•	2	•	s
trichloroethylene	2	10	2	Q	2	•	2	•	30
Base/Neutral Communication									
bis(2-ethylhexyl)phthalate	QN	QN	2	2	Q.	•	2	•	42
di-n-butyl phthalate	¥	410	9	2	QX	•	2	•	2
1,2,4-trichlorobenzene	2	5 2	Q	Q	£	•	3	•	₹
Pesticides/Herbicides									
Aldrin	<0.003	<0.003	<0.003	<0.003	<0.003	•	<0.003	•	<0.003
alpha-BHC	<0.00	<0.002	<0.002	<0.002	<0.002	•	<0.00>	•	<0.003
beta-BHC	*00.00	60.004	*00.0	40.004	*00.0 >	•	<0.004	•	0.021
de I ta - BifC	*00.00	<0.004	0.121	*00.00	¢0.00	•	*00.00	•	*00.00
qamma-BHC (lindane)	0.012	<0.002	0.038	910.0	0.041	•	<0.00>	•	<0.003
chlordane	*0.0	40.0 4	*0.0	*0.0	*0.0	•	*0.0	•	*0.0
000 (108)	<0.012	<0.012	<0.012	<0.012	<0.012	•	<0.012	•	<0.012
DO!!	*00.00	<0.00	<0.006	°0.006	900°0 >	•	00.00	•	40.00
DOT	<0.016	0.016	*0.016	40.016	<0.016	•	<0.016	•	40.016
dieldrin	<0.006	*00.00	°0°00	900.0 >	<0.00	•	40.00	•	900°0°
endosulfan I	<0.00	<0.00>	<0.00	<00.00	<0.00>	•	<0.00	•	<0.00>
endosulfan II	(0.01	(0.01	(0.01	(0.01	(0.0)	•	(0.0)	•	(0.0)
endosulfan sulfate	<0.03	<0.03	<0.03	(0.03	<0.03	•	(0.03	•	(0.0)
endr in	<0.00	600.0 0	<00.0>	600.0 0	<0.00	•	600.00	•	600.0 0
heptachlor	0.013	<0.002	<0.002	<0.002	<0.00	•	<0.002	•	<0°.00
heptachlor epoxide	0.013	*00.0	*00.00	*00.0	*00.00	•	₹00.0 0	•	*00.00
methoxychlor	<0.02	<0.02	<0.02	<0.03	<0.02	•	<0.02	•	<0.02
toxaphene	<0.40	04.0>	<0.40	<0.40	<0.40	•	0.4 0	•	<0.40
2,4-0	(0.00)	(0.00)	(0.001	(0.001	(0.001	•	(0.001	•	(0°0)
2,4,5-T	<0.001	(0.00)	(0.001	(0.001	(0.001	•	*00.00	•	(00.00)
2.4.5-TP (Stlvex)	000	100 01	. 30	,000	20.0	•	000	•	600

TABLE 4.10

STAGE II MELLS
TRACE METALS IDENTIFIED IN GROUNDMATER SAMPLES
MCCLELLAN AFB, CALIFORNIA
(CONCENTRATIONS IN Mg/1)

				17 9 %	Well Number and Sampling Date	d Samiling	Date				4
	338	348	358	368	375	395	405	415	428	438	CA DWS
Metal	9-29-82	9-28-82	9-14-82	9-29-83	9-28-82	9-14-82	9-29-82	9-14-82	9-27-62	9-14-82	(mg/1)
Antlmony (Sb)	10°0 >	•	•	(0.01	(0.0)	,	(0.0)	(0.01	(0.0)	(0.01	N.S.
Arsenic (As)	<0.05	ı	ı	<0.05	<0.05	,	<0.05	<0.05	<0.05	<0.05	0.05
Cadmium (Cd)	(0.0)	ı	ı	(0.01	(0.01	1	(0.0)	(0.0)	(0.0)	(0.0)	0.0
Chromium (Cr)	<0.05	ı	1	<0.05	<0.05	,	<0.05	(0.05	<0.05	<0.05	0.02
Copper (Cu)	<0.05	,	1	<0.05	<0.05	ı	<0.05	<0.0 5	<0.05	<0.0>	1.0
Laad (Pb)	0.018	,	1	610.0	0.01	1	0.013	<0.02	(0.0)	<0.02	0.02
Mercury (Nq)	<0.0005	1	,	<0.000	<0.0005	1	<0.000\$	<0.000\$	<0.0005	<0.000\$	0.003
Mickel (N1)	<0.05	1	ı	<0.05	<0.05	,	<0.05	<0.0>	<0.05	<0.05	.S. 5
Selentum (Se)	(0.0)	1	I	0.01	(0.01	,	(0.01	(0.0)	(0.01	(0.0)	0.01
Silver (Ag)	<0.05	1	ı	<0.05	<0.05	1	<0.05	<0.05	<0.05	<0.0>	0.05
Zinc (Zn)	<0.02	,	•	<0.03	40.02	1	<0.02	(0.02	¢0.04	c0.0 2	5.0

TABLE 4.10 (Continued)

			3	Well Number and Sampling Date	and Samplin	g Date			•
Metal ^a	44S 9-13-82	458 9-14-82	468	478 9-29-82	488	49S 9-29-82	508 9-14-82	38D 9-27-82	Ca DMS ^b (mg/1)
Antimony (Sh)	(0.01	(0.0)	40.01	(0.01		40.01		(0.0)	Z.S.C
Arsenic (As)	\$0.05	<0.05	<0.05	<0.05	•	<0.05	1	<0.05	0.05
Cadmium (Cd)	(0.01	(0.01	(0.0)	(0.01		(0.01	4	(0.0)	0.01
Chromium (Cr)	<0.05	<0.05	<0.05	<0.05	,	<0.05	•	<0.05	0.05
Copper (Cu)	<0.05	<0.05	<0.05	<0.05	ı	<0.05	1	<0.05	0:0
Lead (Pb)	<0.02	<0.02	0.018	0.017	1	9.016	•	(0.01	0.05
Mercury (Hq)	<0.000\$	<0.000.0	40.000\$	<0.0005	,	<0.0005	•	<0.0005	0.002
Nickel (Ni)	<0.05	<0.05	<0.05	<0.0>	1	<0.0>	1	<0.0>	N.S.C
Selenium (Se)	(0.01	(0.01	(0.01	(0.0)	ı	(0.01	ı	(0.01	0.01
Silver (Aq)	<0.05	<0.05	<0.05	<0.05	1	<0.05	ı	<0.05	0.05
Zinc (Zn)	<0.02	<0.02	<0.02	<0.02	ı	<0.02	1	60.0	5.0

(-) = no sample (well dry) a See Appandix M for a complete list of analyses performed. b Ca DMS - California Drinking Water Standard (California Domestic Water (Nality and Monitoring Regulations, California Department of Health Services, 1977). Values listed for copper and zinc are Secondary Drinking Water Standards. C N.S. - No standard has been established for drinking water.

Stage II wells were lower than the California secondary drinking water standard of 5.0 mg/l.

Selected Analyses

In addition to EPA priority pollutant and trace metal analyses, selected analyses were performed on Stage I and Stage II monitoring well samples. These data are presented on Tables 4.11, 4.12 and 4.13. The rationale for conducting these analyses was based on historical Base usage and/or disposal. Analyses included: a cresylic acid (cresol), aliphatics (grease and oil), polychlorinated biphenyls (PCB's), and cyanide. The three wells tested for cresylic acid were MW26S, MW26D, and MW40S. Well 40S contained a detectable concentration of cresylic acid (26 μ g/l), where wells 26S and 26D did not (<5 μ g/l). Uses for cresol depend on its isomer, although generally it has been used for making synthetic resins. The meta isomer is used for fumigants and in photographic developers and explosives. The ortho isomer is used as a solvent. The occurrence of cresol in the groundwater is discussed in more detail later in this section with specific reference to monitoring wells 26S, 26D, and 40S, located downgradient from Site 38 in Area A.

Aliphatic material was determined to be present in wells 20S and 20D after observing a grease film layer 1/4 to 1/2-inch thick on the water surface during sampling of MW20S. Results showed MW20S to contain 915 mg/l of grease and oil, while MW20D contained 1.8 mg/l. A subsequent sampling of MW20D after extended pumping showed no detectable levels of aliphatic material. Because of the extremely elevated levels of grease and oil in the shallow aquifer, it is probable that material was transferred to the deeper zone during drilling, resulting in detectable concentrations during initial analyses. Possible sources of the aliphatic material in the well are addressed later in the discussion pertaining to Area C.

PCB analyses were performed on all Stage I and Stage II monitoring wells with water present. No PCB's were detected in the wells. A more detailed discussion of MW17S and MW17D, located downgradient of Site 46 from which PCB materials have been removed, is contained later in this section.

TABLE 4.11

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STAGE I SHALLOW WELLS
SELECTED CONSTITUENTS IDENTIFIED IN GACHNOWATER SAMPLES
MCCLELLAN AFB, CALIFORNIA

				Well Num	Well Number and Sampling Date	pling Date			
Constituent	Unit of Heasurement	168 8-17-82	178 8-17-82	16.8	198 8-16-82	208 8-11-82	218 8-13-62	228 6-13-62	236
Cresylic acid (Cresol)	1,9/1	•	1	ı	•	1	1	•	•
Cyanide (CM)	1/64	0.03	< 0.02	< 0.02	< 0.02 < 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Polychlorineted biphenyle (PCB'e)	ądd	2	Q.	2	2	2	2	2	9
Aliphatics (grease and oil)	1/6	•	,	•	1	918	ı	•	1
	, ,	248	258 0-12-82	268 8-11-82	278 8-12-82	268	298	30	31 0-17-02
Cresylic acid (Cresol)	1,9/1	i	1	ů	1	•	ı	•	•
Cyanide (CN)	mg/1	< 0.02	0.15	0.02	< 0.03	•	0.95	< 0.02	< 0.03
Polychlorinated biphenyla (PCB's)	qdd	2	2	2	2	Q	Q	ð	9
Aliphatics (grease and oil)	mg/1	1	•	1	•	•	1	,	•

ND = not detected (-) = sample not analyzed for this constituent • = no data (well dry)

TABLE 4.12

STAGE I DESP MELLS
SELECTED CONSTITUENTS IDENTIFIED IN GROUNDMATER SAMPLES
MOCLELLAN AFB, CALIFORNIA

				Well Num	Well Number and Sampling Date	ling Date		-
Constituent	Unit of Measurement	16D 8-17-82	17D 8-17-82	18D 8-16-82	190 8-16-82	20D 8-11-82	21D 8-13-82	22D 8-13-82
Cresylic acid (Cresol)	1/611	,	*	ı	1	,	•	•
Cyanida (CN)	1/64	< 0.02	< 0.02	< 0.02	< 0.02 <	< 0.02	0.05	< 0.02
Polychlorinated biphenyla (PCB's)	qdd	Q.	Ç	<u>Q</u>	Ş	9	<u>Q</u>	9
Aliphatics (greame and oil)	m 9/1	t	ì	•	1		•	r
		230 8-13-82	24D 8-12-82	25D 8-12-82	260 8-11-82	27D 8-12-82	20D 8-17-62	290 8-16-82
Cresylic acid (Cresol)	1/61	ı	1	ı	w ✓	t	•	ı
Cyanide (CN)	mg/1	< 0.02	< 0.02	< 0.02	< 0.03	< 0.02	< 0.02	< 0.02
Polychlorinated biphenyla (PCB's)	qdd	Ş	2	2	Q	ON.	Q.	Q
Aliphatics (grease and oil)	1/6	1	,	•	•	•	•	1

ND - not detected (-) - sample not analyzed for this constituent

TABLE 4.13

STACE II WELLS
SELECTED CONSTITUENTS IDENTIFIED IN GROUNDWATER SANPLES
MCLELLAN AFB, CALIFORNIA

					Well	Well Number and Sampling Date	Sampling De				
Constituent	Unit of Measurement		338 9-29-82	348 9-28-62	358 9-14-62	368 9-29-82	378 9-28-62	195 9-14-82	408 9-29-82	415 9-14-82	428 9-27-82
Cresylic acid (Cresol)	1/6"		t	,	,	1	,	•	92	-	
Cyanide (CN)	mg/1	Ş	< 0.02	•	•	0.03	< 0.02 <	< 0.02	< 0.02	ć 0.02	< 0.02
Polychlorinated biphenyle (PCB's)	qdd (*		g	•	•	Q	Ç	•	ğ	ş	OM
Aliphatics (grease and oil)	mg/1		5.7	•	ı	•	ı	ı	•	•	1
		438	448	458	468	478 9-29-82	468	49S 9-29-82	5 508 -82 9-14-82	-62	36D 9-27-82
Cresylic acid (Cresol)	1/6 11	ı	ı	•	ı	•	•	•	,	,	ı
Cyanida (CN)	1/6=	<0.02	< 0.02	< 0.02	0.03	< 0.02	•	< 0.02	•	•	(0.02
Polychlorinated biphenyls (PCB's)	qdd (•,	ę	Q.	Q	ę	9	•	Q.		•	Q.
Aliphatics (grease and oil)	1,9*1	•	•	•	•	1	•	•			ı

ND = not detected

(-) = sample not analyzed for this constituent

• = no data (well dry)

Cyanide analyses were performed on all Stage I and Stage II monitoring wells that contained water. Cyanide use is widespread, particularly in electroplating baths and for fumigation. Concentrations of cyanide above limits of detection were found in seven wells including MW16S, MW25S, MW26S, MW29S, MW36S, MW46S, and MW21D. No specific past or present disposal site is located near MW29S, in which 0.95 mg/l of cyanide was detected. However, as mentioned earlier in this chapter, trace metal concentrations were notable in MW29S. An area previously used to dispose metals/ electroplating waste is therefore likely to be nearby.

While analyzing the groundwater samples from all wells, a number of non-priority pollutants were identified using GC/MS, but their concentrations were not quantified. A list of these compounds is included in Appendix M.

Monitored Source Areas

The locations of the 46 disposal and storage sites identified in Phase I of the Installation Restoration Program formed the basis for selection of Phase II monitoring well locations. Most of the sites were perceived as forming a number of discrete clusters or source areas throughout the Base. Stage I of the field program was designed to identify potential groundwater contamination from these individual sites and site clusters, and the Stage II program was implemented to further define source locations and single sources within a cluster that had shown evidence of affecting the groundwater.

Table 4.14 delineates the relationship between the sites or site clusters and monitoring wells installed by the Base and by ES during the Phase II field program. Listed on Table 4.15 are the constituents believed to have been stored and/or disposed at specific sites and site clusters, along with the constituents identified in monitoring wells located upgradient and downgradient from each source area. Table 4.16 identifies wells in each monitored site area that contain volatile organics, in conjunction with disposal sites upgradient from these affected wells. The range of concentrations of the most common volatile constituents in groundwater samples from affected wells in each area are presented in Table 4.17. Following are brief discussions of potential

TABLE 4.14

SOURCE AREAS/SITES AND CORRESPONDING MONITORING WELLS
McCLELLAN AFB, CALIFORNIA

Source Areas/Sites	Upgradient Monitoring Wells	Downgradient Monitoring Wells
AREA A		
Sites 25,37,38,39,40	8; 9; 49s	25S,D; 26S,D; 27S,D; 28S,D; 39S; 40S
AREA B		
Sites 30,35,36	25s,D	6; 23S,D; 41S
AREA C		
Subarea C-1 Sites 17,18,19,20,21, 22,28,32,41, 42,43	37 S	20S,D; 21S,D; 22S,D; 33S; 34S; 45S
<u>Subarea C-2</u> Sites 7,8,9,10,11, 12,13,14,15,16	37s	36S; 44S; 2
AREA D		
Sites 1,2,3,4,5,6, 26,27,33	198,D	38D; 1; 10; 11; 12; 13; 14; 15
Site 23		48S
Site 24		24S,D
<u>Site 29</u>		43S
<u>Site_31</u>		43S
Site 34		468
Site 45		185,D
Site 46		175,D

TABLE 4.15

CONSTITUENTS IDENTIFIED IN MONITORING WELLS
ASSOCIATED WITH SOURCE AREAS/SITES

Site	Stored in Area	Constituents Identified in Associated Monitoring Wells Downgradient Upgradient	Upgradient
AREA A	refues/esh	Holmetile scenario	Walshilly generalized
	ethylene dichloride		CONTRACTOR CONTRACTOR
			carpoil terrachiorine
	Cresylle acid	Actd compounds:	chioroform
	soup seulaton	pentachlorophenol	10E
	or thodichlorobensene	Pesticides/herbicides:	Base/neutral compounds:
	skimming bond sludges	Aldrin	bis(2-ethylhexyl)-
	industrial wastewater	alpha-BHC	phthalate
	al udges	beta-BHC	Pesticides/herbicides:
	unknown materials	games-BHC (lindane)	Aldrin
		heptachlor	alpha-BHC
		heptachlor epoxide	beta-BHC
		2,4-0	gamma-BHC (lindane)
		2,4,5-T	heptachlor
		2, 4, 5-TP (Silvex)	heptachlor epoxide
		Trace metals:	2,4-D
		antimony	2, 4, 5-T
		cadatum	Trace metals:
		chromitum	antimony
		copper	cadatus
		mercury	chromium
		zinc	copper
		Other constituents:	lead
		cyanide	mercury
		cresylic acid	nickel
			Delenium
			zinc
AREA B	TCE	Volatile compounds	Volatile compounds:
	Freon	TCE	TOP
	diethyl ether	1,1-dichloroethylene	Pesticides/herbicides:
	low-level radioactive	Base/neutral compounds:	endrin
	washwater	bis(2-ethylhexyl)phtha-	heptachlor
	scrap steel	late	2,4-D
	plating chemicals	1, 2, 4-trichlorobenzene	2, 4, 5-T
		Pesticides/Nerbicides:	Trace metals:
		alpha-BHC	chromium
		gamma-BHC (lindane)	ginc
		heptachlor	Other constituents:
		2,4-D	cyanide
			•

TABLE 4.15 (Continued)

Source Area/ Site

Materials Reported Disposed/	Constituents Identified in	Constituents Identified in Associated Monitoring Wells
Stored in Area	Downgradient	Upgradient
	Trace metals:	
	antimony	
	arsenic	
	chrostus	
	copper	
	A Lenica	
	nickel	
	selentum	
	zinc	
refuse, ash, and residue	Volatile compounds:	Pesticides/herbicides:
industrial wastewater	benzene	delta-BHC
eludge	chloroform	2, 4, 5-T
metal plating wastes	ethylbentene	Trace metals:
TCE/wasta solvents	toluene	lead
paint vestes	1,2-trans-dichloro-	
tuels and oils	ethylene	
PCB wastes	TCE	
waste chemicals	Acid compounds:	
cyanide wastes	pentachlorophenol	
low-level radioactive	Base/neutral compounds:	
Zantes	anthracena	
herbicide/pesticide	Dis(2-ethylhexyl)-	
containers	portnaiste Atophysical shebelete	
todate the contra		
describition debries		
	Description Court of App.	
	Aldrin	
	a toha - BHC	
	beta-BHC	
	delta-BHC	
	gamma-BHC (lindane)	
	endosulfan I	
	endosulfan sulfate	
	2, 4, 5-T	
	2, 4, 5-TP (Silvex)	
	Trace metals:	
	antimony	
	arsenic	
	cadmium	
	chromium	
	lead	
	Bercury	
	selentus.	
	zinc	

TABLE 4.15 (Continued)

Source Area/ Site

Subarea C-2

		Upgradient
	Other constituents:	
	cyanide	
	grease and oil	
industrial sludges	Volatile compounds:	Pesticides/herbicides:
rue is and of its	tetrachloroethylene	delta-BHC
TCE/waste solvents	1,1-dichloroethylene	2, 4, 5-T
	10 P	Trace metals:
Creek debris	Base/neutral compounds:	lead
Paint wastes	bis(2-ethylhexyl)-	
Bewage sludge	phthalate	
	1, 2, 4-trichlorobenzene	
metal plating wastes	Trace metale:	
Waste chemicals	selentus	
Cyanide westes	Other constituents:	
IOV-IEVEL FACTOACTIVE VARIES	cyanide	
nerbicide/pesticide containers	Pasticides/herbicides:	
Solium Valves	delta-BHC	
	gamma-BHC (lindane)	
	heptachlor epoxide	
	2,4-D	
refuse/solid waste	Volatile compounds:	Acid compounds:
industrial sludges	hensened	nent ach lore others
fuels and oils	chloroform	Rese/neutral communication
TCE/waste solvents	1. 1-dichlorosthans	Pie (2-eth.) be)
modium valves		Distant in the sail of the sai
	1, 1 - alchioroethylene	Featicides/herbicides:
	1,2-trans-dichloro-	dieldrin
	ethylene	gamma-BHC (lindane)
	methylene chloride	heptachlor
	tetrachloroethylene	2,4-0
	toluene	2,4,5-TP (Silvex)
	1, 1, 1-trichloroethane	Trace metale:
	1,1,2-trichloroethane	antimony
	TCE	arsenic
	trichlorofluoromethane	cadeium
	vinyl chloride	chromium
	Acid compounds:	copper
	2, 4-dimethylphenol	lead
	phenol	mercury
	Base/neutral compounds:	nickel
	bis(2-ethylhexyl)-	selentum
	phthelate	zinc
	1,2-dichlorobenzene	
	1, 3-dichlorobenzene	
	1.4.Aichlorobeneane	

AREA D

Source Area/ Site

Materials Reported Disposed/ Stored in Area	Constituents Identified in Associated Monitoring Wells Downgradient Upgradient
	Pesticides/herbicides: Aldrin
	Deta-BHC
	2, 4, 5-T
	2,4,5-TP (Silvex)
	but bony
	cadmium
	chromium
	lead
	nickel
	selenium sinc
no information available	no data
	•
descrittion debris	Actd compounds:
Tamper and paper scrap	pactal des Arethic des
	Commanda (100 dece)
	Trans patelle.
	zinc
scrap saterial	Pesticides/herbicides:
drums	gamma-BHC (lindane)
transformers (PCB's)	heptachlor
generators	heptachlor epoxide
	2,4,5-TP (Silvex)
refuse/solid waste	Pesticides/herbicides:
484	gamma-BHC (lindane)
	heptachlor
	heptachlor epoxide
	2,4,5-TP (Silvex)
waste solvents	Volatize compounds:
	chloroform
	Pesticides/herbicides:
	gamma-BHC (lindane)
	Trace metals:
	Other constituents:
	Cyantae

Site 29

Site 31

Site 34

Site 23

TABLE 4.15 (Continued)

Source Area/ Site	Materials Reported Disposed/ Stored in Area	Materials Reported Disposed/ Constituents Identified in Associated Monitoring Wells Stored in Area Downgradient
Site 45	waste paint (latex-based 7)	Acid compounds: pentachlorophenol Base/neutral compounds: bis(2-ethylhexyl)phthalate Pesticides/herbicides: Aldrin alpha-BHC gamma-BHC gamma-BHC data-BHC gamma-BHC 2, 4-5 2, 4-5 Trace metals: cadmium mercury
81 te 46	no information available (identified PCB surface contamination)	Trace metals: antimony mercury Pesticides/herbicides: Aldrin 2,4-p 2,4,5-T Base/neutral compounds: his (2-a-thu) habbalate

TABLE 4. 16

IDENTIFICATION OF DISPOSAL SITES UPGRADIENT FKM AFFECTED WELLS CONTAINING VOLATILE ORGANIC CONSTITUENTS

			Monitoring Wells	19 Wells		
Monitored Area/Site	Monitor	Monitoring Wells adjent Downgradient	Volatile Organ Upgradient Dov	Volatile Organics pgradient Downgradient	Disposal Sites Upgradient from Affected Wells	Contributed to Groundwater Degradation?
Area A						Yes
25, 37, 38, 39, 40	© (os c		(General TCE-use area)	
	\$6.	258, D	.	255,0	25, 37	
		278,0 288,0		275	39, 40	
		396 408		408	36	
Area B						Z e
30, 35, 36	25s, D	۰		ve	30	
		238,D 418		415	36	
Area C Subarea C-1						Yes
17, 18, 19, 20, 21,	378					
22, 28, 52, 41, 42, 43		208, D 2 18, D		205 215	43 (Subarea C-1)	
		228,0 338 348		225 335	(Subarea C-1)	
		458				
Subarea C-2						Yes
7, 8, 9, 10, 11, 12, 13, 14, 15, 16	378	366				
		448		4 .45	9, 10, 11	

TABLE 4.16 (Constanted

			Monitoring Wells Containing	Disposal Sites	Has Area Contributed to
Monitored Area/Site	Monitori Upgradient	Monitoring Wella radient Downgradient	Volatile Organics Upgradient Downyra-lient	Upgradient from Affected Wells	Groundwater Degradation?
					Yes
1, 2, 3, 4, 5,	198,0				
6, 26, 27, 33		36	360	4, 5, 6, 26	
		- :	- ;	~ ,	
		2 :	2:	<i>.</i>	
		: 2	12	ò	
		13	13	5, 6	
		=	**		
		25	15	1, 27	
Site 24		248,D			9
Site 29		€ 38			2
Bite 31		4 38			ç
Site 14		468			ì
Bite 45		188,D			9
S1te 46		178,0			â
Upgradient Base Boundary					ž
		168,D 31			
		2			
Downgradient Base Boundary					e e X
		208,D	205	(Subarea C-1)	
		238			
		248,0 286.0			
		348			
		358 368			
		96			
		428			
		478			
		8 2	5	10	
		Ξ	Ξ	(4:::0)	
		51	4	(A) (A)	

TABLE 4.17

RANGE OF VOLATILE ORGANIC CONSTITUENT CONCENTRATIONS IN GROUNDWATER FROM DIFFERENT SOURCE AREAS

Source Area	Disposal Sites Upgradient From Affected Wells Containing Volatile Organics	Range of Concentrations of Most Common Volatile Constituents in Groundwater
AREA A	25, 37, 38, 34, 40	trichloroethylene: ND-50 ppb
AREA B	30,36	1,1-dichloroethylene: ND-5 ppb 1,2-trans-dichloroethylene: ND-10 ppb trichloroethylene: ND-118 ppb
SUBAREA C-1	41,42,43	ethylbenzene: ND-220 ppb toluene: ND-440 ppb trichloroethylene: ND-2,000 ppb
SUBAREA C-2	7,8,9,10,11,12, 13,14,15,16	1,1-dichloroethylene: ND-30 ppb tetrachloroethylene: ND-5 ppb trichloroethylene: ND-10 ppb
AREA D	1, 2, 3, 4, 5, 6, 26, 27	1,1-dichloroethylene: 500-63,000 ppb 1,1,1-trichloroethane: ND-12,000 ppb trichloroethylene: 160-14,100 ppb

ND - not detected

source areas and other selected locations on the Base which were monitored during the Phase II field program.

Area A

The constituents identified in the monitoring wells downgradient from Area A correspond to the materials that were disposed in the sites in that area, except for the pesticides and herbicides; however, the wells upgradient from Area A contain constituents for which no apparent source area or areas exist. The sources may be industrial areas at the northern part of the Base. In Area A, Sites 25, 37, 38, 39, and 40 were identified as being upgradient from monitoring wells containing volatile

organics. When groundwater samples from wells in Area A were analyzed for TCE, results ranged from "none detected" (ND) to 50 ppb.

Base production well 7, which was previously abandoned due to the reported presence of cresylic acid, is located downgradient from Building 475 (Site 38). From 1942 until the late 1950's, this site operated as an aircraft reciprocating engine repair shop and solvent recovery area for cresylic acid and dichlorobenzene. Monitoring wells 26S and 26D were installed 1,000 feet downgradient from BW7 and were tested for cresylic acid. Analyses showed concentrations to be lower than detection limits. Based on these results, cresylic acid did not appear to be migrating in the groundwater beyond the production well. Monitoring well 40S was then installed approximately 250 feet downgradient from the production well. Cresylic acid was found to be present in MW40S at a concentration of 26 μ g/1, indicating that past activities at Building 475 could be the source.

Monitoring well 39S is located upgradient from monitoring wells 25S and 25D, and downgradient from disposal site 25 (burial pit). TCE was identified in MW25S and could have originated from Site 25. However, no volatile compounds were detected in MW39S, indicating that the source of TCE in MW25S probably is not currently burial site 25. Monitoring well 27S contained measurable levels of TCE and pentachlorophenol indicating that Site 39 may have caused groundwater problems.

Area B

In Area B Sites 10 and 36 were identified as being upgradient from monitoring wells containing volatile organics. Concentrations in this monitoring area ranged from ND to 5 ppb for 1,1-dichloroethylene; ND to 10 ppb for 1,2-trans-dichloroethylene; and ND to 118 ppb for trichloroethylene. Monitoring well 41S was installed downgradient from MW25S and MW25D, both of which showed the presence of TCE. Well 41S was to aid in establishing the extent of TCE migration. Analysis of the well showed volatile compounds present, including TCE. However, the source may have been disposal site 36, which was used for the open storage of plating shop chemicals from 1958 to 1980. Monitoring well 27S (located downgradient from Area B at the Base boundary) contained 15 ppb of TCE and 120 ppb of pentachlorophenol.

Area C

Subarea C-1. In Subarea C-1 Sites 17, 18, 19, 20, 21, 22, 28, 32, 41, 42, and 43 were identified as being upgradient from monitoring wells containing volatile organic constituents. Concentrations of these volatile compounds ranged from ND to 220 ppb for ethyl benzene; ND to 440 ppb for toluene; and ND to 2,000 ppb for trichloroethylene.

A burial pit designated Site 43 is located near monitoring wells. 20S and 20D. The pit collected demolition debris and probably received spills and discharges of oily wastes in the 1940's. Analysis of MW20S groundwater samples showed the presence of volatile and base/neutral constituents, several trace metals, and a high concentration (915 mg/l) of aliphatics (grease and oil). Installation of MW34S during Stage II was to have more clearly defined the source of aliphatic material found in MW20S. However, the well was dry during sampling (dry season months) and data are not available. Monitoring of MW34S during the wet season will more clearly identify the source. Well 33S was installed downgradient from MW20S to identify potential migration of aliphatic material. Results do show the presence of grease and oil in MW33S (5.7 mg/l). The aliphatic material appears to be moving southward through the groundwater.

Monitoring well 45S was located downgradient from Site 21 (sludge/oil pit) to ascertain potential point source areas for constituent movement to groundwater. However, no constituents were found in the well-

Subarea C-2. In Subarea C-2 Sites 7, 8, 9, 10, 11, and 16 were identified as being upgradient from monitoring wells containing volatile organic constituents. Concentrations of these volatile compounds ranged from ND to 30 ppb for 1,1-dichloroethylene; ND to 5 ppb for tetrachloroethylene; and ND to 10 ppb for trichloroethylene.

Monitoring well 36S is located along the western Base boundary immediately northwest of the burial pits designated as Sites 9 through 14. The well was completed into the shallow aquifer to determine off-base flow of constituents in the groundwater. Constituents do not appear to be leaving the Base in this area; analysis of the well shows it to be virtually "clean".

Monitoring well 44S was located downgradient from Site 15 (sodium valve trench). Well 44S does identify potential point sources for shallow groundwater constituents, although concentrations appear minimal. The only constituents present were 1,2,4-trichlorobenzene (8 ppb), trichloroethylene (10 ppb), and 1,1-dichloroethylene (30 ppb) which were probably not contributed by Site 15.

Area D

In Area D sites 1, 2, 3, 4, 5, 6, 26, and 27 were identified as being upgradient from monitoring wells containing volatile organic compounds. Concentrations for selected volatile compounds ranged from 500 to 63,000 ppb for 1,1-dichloroethylene; ND to 12,000 ppb for 1,1,1-trichloroethane; and 160 to 14,100 ppb for trichloroethylene.

Monitoring well 37S is located immediately downgradient from disposal site 33. This site was used for temporary (2 to 4 months) land-farming of industrial waste treatment sludge during 1972. Although MW37S was located near a possible source of material, constituents were not detected in the well.

Monitoring well 38D at the western boundary of the Base was completed in the second sands. The surrounding area contains several monitoring wells installed by the Base in 1980. All of the Base monitoring wells have shown high concentrations of organic constituents at each sampling period during the past two years. Sources of these constituents are located in disposal sites clustered to the east of MW38D (Sites 4, 5, 6, and 26). Each of these waste disposal sites contains various buried materials including industrial sludge and oil, fuel, and solvents. Analyses of MW38D reveal the presence of particularly volatile constituents. However, because of the extremely elevated concentrations of these constituents found in the shallow sands, it is presumed that these were transferred to the deeper aquifer during drilling of MW38D.

Analysis of samples from monitoring wells 10 through 15 revealed consistently high levels of TCE and other volatile organics. Monitoring wells 10, 11, and 15 were located in proximity to the downgradient Base boundary in this area.

Site 24

Located downgradient at a distance from Site 24, monitoring wells 24S and 24D did not reveal the presence of significant levels of constituents.

Site 29/Site 31

Monitoring well 43S (located downgradient at a distance from both Site 29 and Site 31) did not contain volatile organics or trace metals. This indicates that these sites probably are not causing groundwater quality problems.

Site 34

Monitoring well 46S was placed immediately adjacent to past disposal site 34 (underground waste solvent storage tanks). The tanks do not appear to be point sources for movement of constituents to groundwater. Analytical results show only chloroform (5 ppb), lead (0.018 mg/l), and cyanide (0.02 mg/l) detected.

Site 45

Monitoring wells 18S and 18D were located downgradient from Site 45, a paint burial pit which was operated in the 1950's. Analytical data for these two wells show that they are practically "clean". Excluding the herbicides and pesticides, detectable compounds in MW18S included: pentachlorophenol (6 ppb), bis(2-ethylhexyl)phthalate (8 pbb), and mercury (0.0016 mg/l). Well 18D contained only bis(2-ethylhexyl)phthalate (12 ppb) and cadmium (0.09 mg/l). Constituents from this site do not appear to be migrating into groundwater.

Site 46

Disposal site 46 is the location of an old salvage yard operation where PCB contamination had been identified in surface soil in a small area adjacent to the runway clear zone. Salvage operations were conducted by a previous owner from the mid-1960's through 1978. The site is located at the northwestern corner of the Base, with groundwater flow toward the southwest. The soils containing PCB's were removed by the Air Force in a program approved by the state DOHS and the Central Valley RWQCB and transported to a permitted PCB site. Site 46 comprised about

2.6 acres and at some points was excavated to a depth of two feet. Material was removed that had PCB concentrations greater than 50 ppm. The excavation was started in July 1981 and was completed in September 1981. The material was transported to the Grandview Site B disposal facility (ID Number IDD07314654) in Grandview, Idaho.

Wells 17S and 17D were located directly downgradient from the disposal site to determine the extent of PCB migration, if any. PCB's were absent from all monitoring wells on the Base, including MW17S and MW17D.

Upgradient Base Boundary

The location of monitoring wells 16S and 16D was selected to determine the quality of the groundwater entering McClellan AFB. The shallow well, MW16S, showed the presence of pesticides and herbicides, but no volatile, acid, or base/neutral compounds were detected in this well. Cyanide was detected in the shallow well at 0.02 mg/l. In subsequent sampling of MW16S, 1,1-dichloroethylene and TCE were each identified at concentrations of 10 parts per billion. This shallow well was resampled on 8 October 1982, and no constituents were identified other than pesticides and herbicides. Other background wells were also relatively "clean".

Downgradient Base Boundary

Monitoring well 42S was located at the southern Base border to identify potential constituent migration from the Base. Analytical results showed no constituents detected, except zinc at 0.04 mg/l.

Monitoring well 43S was installed along the southwestern border of the Base to identify potential off-base movement of constituents in the shallow aquifer. Monitoring well 7, located just south of MW43S, has shown TCE concentrations in the past. However, analysis of MW43S detected no constituents.

Monitoring well 47S was located near the southwestern Base boundary to identify potential migration of groundwater constituents off Base. Lead was the only constituent present in the groundwater, showing a concentration of 0.017 mg/l.

Monitoring well 20S located at the middle of the western Base boundary in Subarea C-1 contained measurable levels of trace metals as well as 45 ppb of benzene, 220 ppb of ethyl benzene, and 440 ppb of toluene at one sampling.

Monitoring wells 10, 11, and 15 were located at the northwestern Base boundary downgradient from Area D. Appreciable levels of volatile organics were measured in groundwater samples from these wells. For example, 1,1-dichloroethylene was measured at 19,300 ppb and 63,000 ppb in two successive samplings at well 11.

Industrial Waste Line Survey and Soil Sampling Near Building 251

During investigation of the industrial waste line near Building 251, the 6-inch PVC force main passed the air test at 4 psi and 9 psi. The force main is therefore assumed to be in acceptable condition. All industrial gravity sewers tested failed the air test, indicating a high potential for exfiltration of waste. The industrial gravity sewer is in excess of 38 years old. It is likely that the joints are flush-bell-and-spigot-with-mortar joints and that the majority of these joints may leak. The abandoned 4-inch force main, which discharged to the manhole 33 outlet, should at least be plugged at the manhole 33 outlet and should perhaps be removed entirely.

In 1944 manhole 33A was replaced with a vapor trap structure by the US Army Corps of Engineers. The abandoned manhole 33A and inlet and outlet lines were left in place and available plans indicate that they were plugged. This manhole is now partially filled with sludge. The manhole and lines should be removed and disposed. The replacement vapor trap structure traps sludge and should be periodically flushed.

In 1944 a manhole in the vicinity of manhole 30 was also replaced by a vapor trap structure. In 1954 the vapor trap structure or bypassed by manholes 92, 30, and 30A. From the Corps of Engineers plan of 1954, it appears that there are two 15-inch drains from Building 251 and an 18-inch storm drain overflow still connected to the abandoned vapor trap structure and that all the outlets were plugged.

No volatile, acid, or base/neutral compounds were identified above detection limits in any of the soil samples obtained during drilling

under the industrial waste line near Building 251. A number of pesticides and herbicides were present in all the samples. Table 4.18 presents the results for organic analyses of soil samples collected at this site.

Trace metals were detected in all of the soil samples obtained beneath the industrial waste line. These data are presented in Table 4.19. Generally, metals showed highest concentration levels in the first soil boring at a 15-foot depth, where arsenic was detected at 137.5 mg/kg and selenium at 23.7 mg/kg.

HYDROGEOLOGIC REGIME

The hydrogeological investigations conducted during the field program resulted in the identification of three different conditions under which water occurs: (1) as perched water within shallow, discontinuous, and localized water-bearing material at depths ranging from 30 to 50 feet; (2) under unconfined conditions within shallow water-bearing sands ranging in depths from about 80 to 100 feet; and (3) within deeper water-bearing material at over 120-foot depths, consisting of numerous aquifers with water under confined conditions.

Perched Water

The perched water is of a localized nature, with no continuity off the Base. There are no monitoring wells installed in these perched zones and therefore no data on the quality of that water. Since the areal extents of the perched zones are limited, migration of that water is not considered likely. The analytical results of groundwater samples from the deeper water-bearing materials indicate a range of concentrations of chemical constituents that is below established standards. As a consequence, the main focus of the hydrogeological investigations has been to establish the characteristics of the water-bearing materials found at a depth of about 80 to 100 feet. It is within this stratum that the highest concentrations of chemical constituents were found throughout the Base.

TABLE 4.18

BUILDING 251 SOIL BORINGS BENEATH INDUSTRIAL WASTE LINE ORGANIC COMPOUNDS IDENTIFIED IN SOIL SAMPLES MCCLELLAN AFB, CALIFORNIA (CONCENTRALIONS IN µ9/kg)

		Bortn	Boring Number/Depth and Sampling Date	nd Sampling Date		
Compound	6-04-82	6-04-82	6-04-82	6-04-82	63/15 feet 6-07-82	83/20 feet 6-07-82
Base/Neutral Compounds naphthalene	Q	2	QX	410	QN	2
Pesticides/Herbicides						
Aldrin	QN	QN	1.44	1.60	1.47	q
qamma-BHC (lindane)	1.40	0.57	1.01	0.70	1.72	1.76
DOE	Q	Q	QN	QN	69.0	Q
dieldrin	G	2.11	QN	2.10	QN	Q X
endosulfan I	2.46	2.51	2.38	0.56	QN	QN
heptachlor	·•·	0.59	1.45	1.70	2.35	2.29
2,4-D	1.40	3.02	0.45	*: *	2.06	2.09
2,4,5-T	2.63	0.81	0.067	1.10	1.87	1.18
2,4,5-TP (Silvex)	0.98	QN	0.224	3.53	4.80	Q.

MD - not detected a See Appendix N for a complete list of analyses performed.

TABLE 4.19

į

BUILDING 25: SOIL BURINGS REMEATH INDUSTRIAL WASTE LINE TRACE METALS IDENTIFIED IN SOIL SAMPLES MCCLELLAN APB, CALIFORNIA (CONCENTRATIONS IN mg/kg)

		Bor	Boring Number/Depth and Sampling Date	th and Sampling	Date	
He tal	6-4-82	\$1/20 feet 6-4-82	62/15 feet 6-4-82	#2/20 feet 6-4-82	6-7-82	6-7-82
Antimony (Sh)	23.1	1.75	3.12	3.37	5.87	4.55
Arsentc (As)	137.5	57.0	82.5	52.5	0. 98	52.5
Cadmium (Cd)	1.27	2.07	1.32	1.0	0.82	1.04
Chromium (Cr)	124.0	75.0	94.0	85.0	95.0	80.5
Copper (Cu)	28.0	0.16	107.0	26.0	26.0	22.0
[ded (Pb)	::	1	7.16	13.6	12.4	14.9
Mercury (Hq)	٠٠٥ >	0.21	٠ 0.1	٠٠٥ >	٠ 0.1	< ٥٠١
Nickel (Ni)	48.5	20.5	32.2	28.5	27.5	27.2
Selenium (Se)	13.7	7.5	17.2	1.1	13.5	10.5
Silver (Aq)	1.5	0.35	0.92	0.8	1.2	98.0
Zinc (Zn)	68,2	54.0	57.2	54.5	53.0	48.9

a See Appendix N for a complete list of analyses performed.

Deeper Aquifers

The deeper water-bearing materials found at depths ranging from 120 feet to 160 feet consist of silty sands that are of medium grain size. Some traces of gravel were found in borings for wells along the eastern side of the Base. The sands appear in at least three distinct levels on the Base at depths of 120 feet, 140 feet, and 160 feet. different zones may not be interconnected. The thickness of the sands may vary and there may be additional lenses at greater depths. within all the deeper sands are under confined conditions with heads averaging 40 feet (i.e., the water levels in the wells are at an average of about 40 feet above the top of the water-bearing sands). were the heads of the confined deeper aquifers observed to be above the shallow groundwater levels. Examination of water level data from the wells penetrating the deeper sands shows a general trend of groundwater flow from north to south. Drawdowns in water levels in the deeper wells range from one to over four feet over a four-month period. The variance in drawdowns could be a result of lenticular and discontinuous sands and/or potential interferences from nearby on-line production wells.

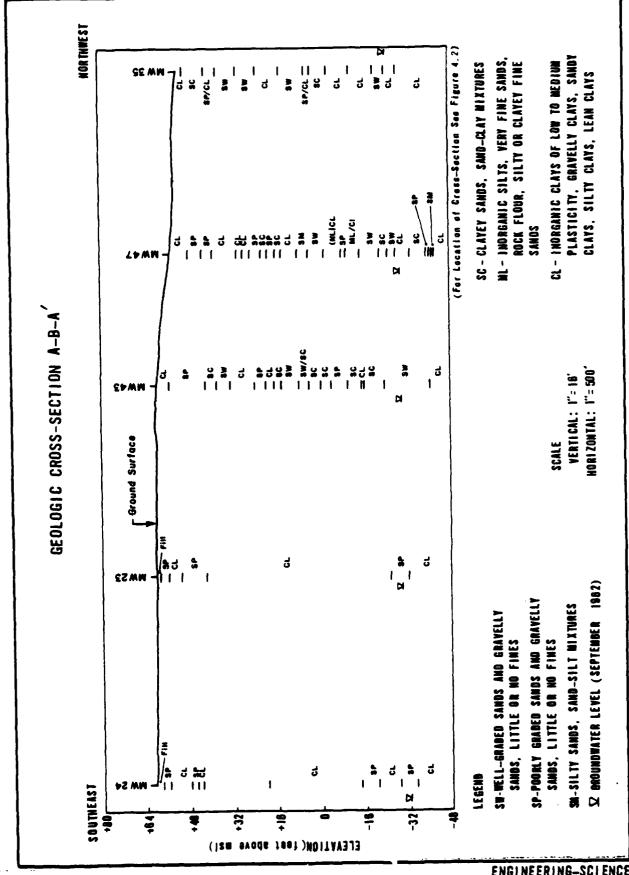
During sampling of the Stage I multiple-completion wells, the deeper wells were pumped to evacuate about five casing volumes of water; during pumping, the water levels within the adjacent shallow wells were monitored to determine potential hydraulic continuity between the deep and shallow water-bearing sands. For the selected wells that were observed, no continuity between the shallow and deep sands was noted. At a constant pumping rate of about 1 gpm during sampling events, none of the deep wells ran dry and only a minimal drawdown (less than one foot) was observed after pumping ceased; one exception was well 19D. which showed about a 7-foot drawdown after three well casing volumes had been removed. The general lack of drawdown in the wells after pumping indicates that the deeper sands are good producers of water. further substantiated by the fact that production wells on the Base draw about 1,100 gpm from the deeper-lying aquifers, including the second water-bearing zone, with a maximum drawdown of 25 feet.

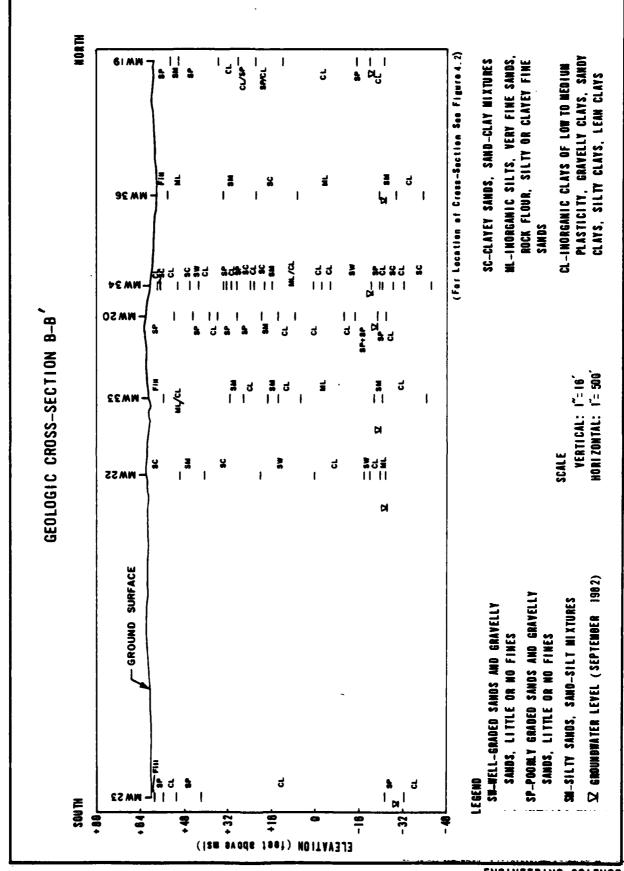
Shallow Sands

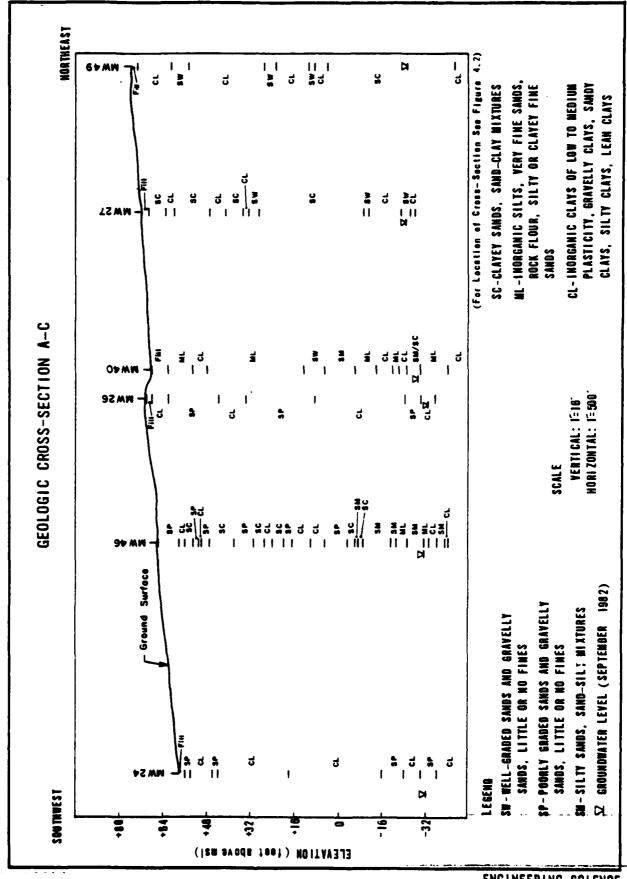
During the entire field program, a total of 32 shallow wells were installed. Throughout the Base, a shallow groundwater table was generally encountered at depths ranging from approximately 80 feet to 100 feet below ground surface, or about 20 feet to 33 feet below mean sea level (water levels were measured in September 1982). The water is contained within fine-grained sands of variable thickness. The water-bearing sands may be discontinuous or have variable permeabilities under the Base. Well logs are presented schematically on Figures 4.3, 4.4, and 4.5 for three cross-sectional areas on the Base; these figures show the intricate interbedded nature of the sediments identified during the field program. The well logs show the sediments above and immediately below the shallow aquifer. A determination of the continuity of the shallow sands is not possible; however, it should be noted that since shallow groundwater is present throughout the Base, it can be assumed that the sands are interconnected, but may vary laterally in permeability.

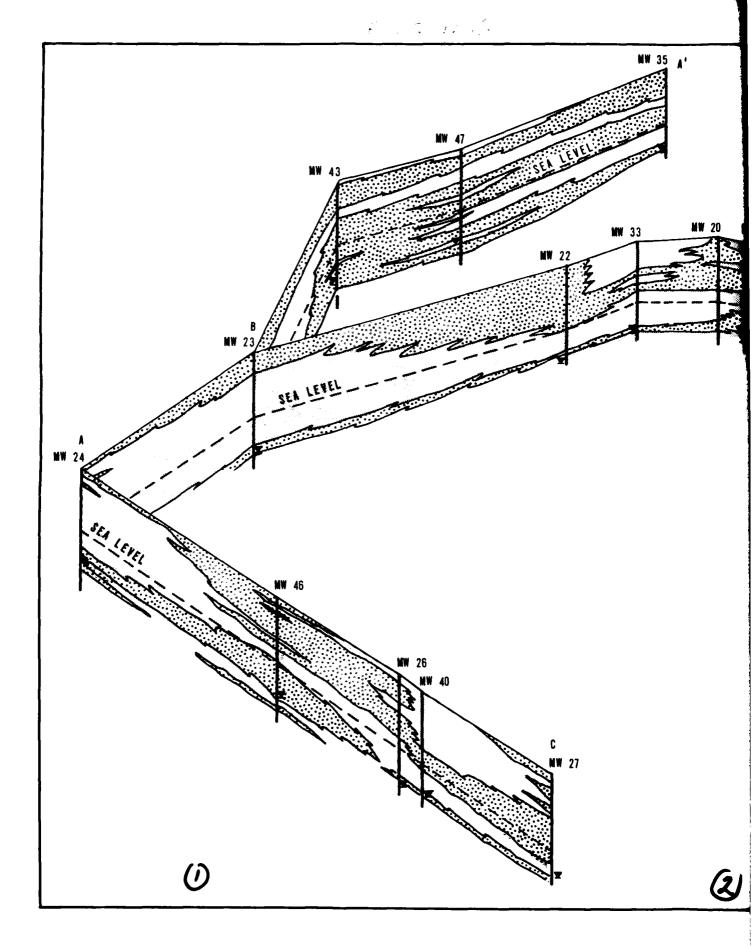
The thickness of the shallow water-bearing sands varies at different monitoring well locations. In the northern part of the Base, the sands were found to be as little as one foot thick, with a general increase in thickness to the south-southwest. In the southern part of the Base by MW43S, the sands reach thicknesses up to 17 feet. The average thickness of the sands is about 6 feet.

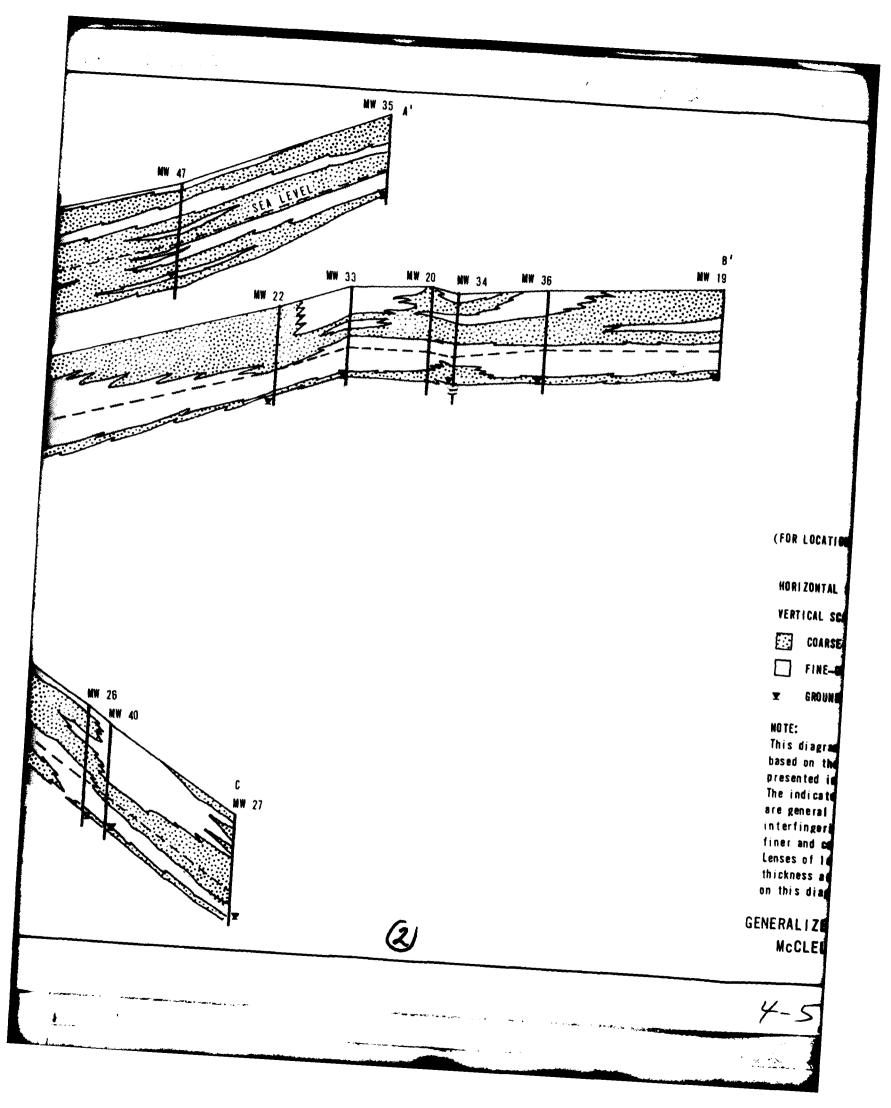
A generalized fence diagram is shown on Figure 4.6. On this diagram, the sediments underlying the Base have been divided into two types of materials: fine-grained (clays and silts) and coarse-grained (sands, silty sands, and clayey sands). This figure was prepared on the basis of data contained in the geologic logs shown in Appendix E. The lateral and vertical extents of the materials and their continuity in the areas between the monitoring well locations are unknown but have been presented diagrammatically to provide an overview of the subsurface conditions; the diagram should not be construed to represent actual subsurface conditions, but should be viewed simply as a graphic presentation of the collected data.





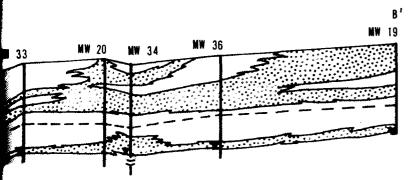












(FOR LOCATION OF CROSS-SECTIONS SEE FIGURE 4.2)

HORIZONTAL SCALE 1" = 1000'

VERTICAL SCALE 1" = 80'

COARSE-GRAINED MATERIAL (SANDS)

FINE-GRAINED MATERIAL (SILTS AND CLAYS)

▼ GROUNDWATER LEVEL

NOTE:

This diagram was prepared based on the geologic logs presented in Appendix O.
The indicated types of sediments are general and contain numerous interfingering lenses of finer and coarser-grained material. Lenses of less than 5 feet in thickness are not included on this diagram.

GENERALIZED GEOLOGIC FENCE DIAGRAM
McCLELLAN AFB, CALIFORNIA

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The shallow water-bearing sands are overlain by coarse and finegrained material. The finer-grained materials (clays and silts) reach considerable thicknesses in places. These sediments generally have very low permeabilities inhibitive to vertical movement of water; hardpan encountered in numerous monitoring well locations likewise restricts vertical transmission of water. Therefore, the groundwater recharge to the shallow sands is probably not occurring directly from precipitation on the Base, but rather from an area upgradient where the sediments surface. The general dip of sediments from the Victor and Fair Oaks Formations is from east to west with a minimum slope of 5 feet per mile (California Department of Water Resources, 1974). Thus, the maximum distance to a recharge area for the shallow water-bearing sands would be about 14 miles east of the Base (assuming an average depth of the sands as 80 feet below the ground surface). Precipitation falling in the recharge area would enter the sands and flow downgradient through the aquifer system. The shallow water-bearing sands are present along the southern Base boundary and continue off Base downgradient toward the City of Sacramento. The exact lateral and vertical extents of the shallow zone are not known, but the Victor and Fair Oaks Formations both extend southward beneath Sacramento. Water within any of the waterbearing sands would travel toward the groundwater trough near the city of Sacramento unless extracted by pumping.

The pump tests performed at MW44S failed to cause responses in the nearby piezometers. However, recovery measurements taken during pumping of well 44S were used to estimate the permeability and transmissibility of the shallow sands in that location. Data from these tests are contained in Appendix C. Transmissibility near MW44S was determined using Jacob's modification to the Theis equation:

$$T = \frac{2640}{\Delta h'}$$

where T = transmissibility (gal/day/ft)

Q = discharge from pump (gal/min)

 $\Delta h' = change in residual drawdown (ft/log cycle of time)$

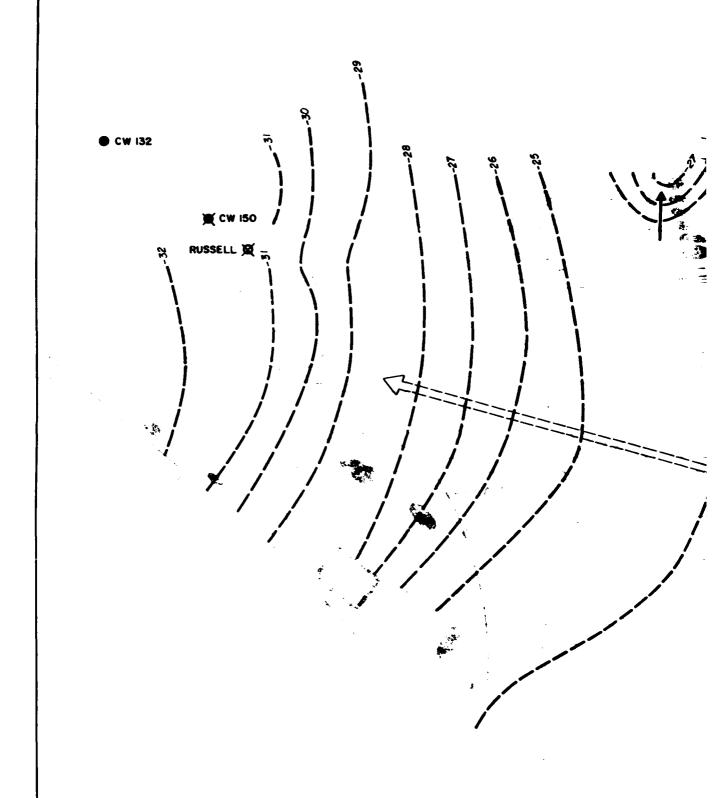
Transmissibility in the shallow zone near MW44S was estimated to be 21 gal/day/ft, based on a pump discharge rate of 0.82 gal/min and a 10-ft change in residual drawdown.

Permeability (K) is obtained from the relationship between transmissibility (T) and aquifer thickness (b), where K = T/b. The permeability for the MW44S area is thus estimated to be 4.2 gal/day/ft², assuming an aquifer thickness of 5 feet. Based on water level measurements taken in September 1982, the groundwater levels on the Base range from 20 feet to 33 feet below sea level in a northeast-southwest direction; this represents a gradient of 3.7 feet per mile. The estimated velocity of the groundwater in the shallow sands in the MW44S area thus would be about 8 feet per year (velocity equals the permeability multiplied by the groundwater gradient). This velocity estimate is localized and does not account for the influence of area pumping or changing aquifer characteristics. Local pumping, especially by adjacent off-base water supply wells, could increase the gradient of the groundwater and therefore increase its velocity in that particular area.

Slug test data, also presented in Appendix O, were analyzed according to the methods described in Lohman (1972):

The slug tests performed on MW24S showed an average transmissibility of about 5 gal/day/ft and a permeability of 0.8 gal/day/ft². This is considerably less than the permeability estimated from the pump test at MW44S. Generally, good aquifers have permeabilities ranging from 10^6 to 10^2 gal/day/ft² while poor aquifers range from 10 to 10^{-2} gal/day/ft², with impervious materials having permeabilities below 10^{-3} gal/day/ft².

Groundwater level data obtained in September 1982 for all ES and Base monitoring wells were used for the development of a generalized groundwater contour map for the Base which is shown on Figure 4.7; these contours assume a continuous shallow aquifer underlying the Base. The general groundwater movement is toward the south-southwest. Pumping of off-base wells along the western Base boundary appears to influence the local groundwater in that area, causing it to flow to the west. Based on the water level measurements taken at the monitoring wells, pumping of Base production wells does not appear to influence the shallow



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groundwater contours in the southern part of the Base. This is probably due to the well design of these production wells. Base production well 17 is a cable-tool well, with perforations below the shallow aquifer, and no gravel pack; Base production well 13 may be constructed similarly since it was installed at approximately the same time as BW17.

The two aquifer tests conducted in the middle of the Base (MW44S) and along the southern boundary (MW24S) showed variability in the thickness and permeability of the shallow aquifer. These tests confirm field observations during well installation and sampling events regarding changing characteristics of the shallow water-bearing zone. rate of movement of water through the shallow sands may therefore vary considerably. Water supply wells located off Base to the southwest and to the west have shown contamination by TCE. To the southwest, ranging from the Base boundary to as far as 3,000 feet from the Base, several private and public water supply wells have been shut down at various intervals since 1980 in response to changing concentrations of TCE in the well water. Immediately inside the southern Base boundary lies the cluster of sites designated as Area B, where materials such as TCE, Freon, diethyl ether, scrap metal, and plating chemicals were probably disposed and stored. The sites in Area B were active from as early as World War II to as late as 1980, or about 40 years.

Along the western boundary, TCE contamination has been detected in wells within 1,000 feet of the Base. Area D is located along the Base boundary closest to the off-site wells that have shown contamination. From the late 1940's to 1981, sites within Area D are reported to have handled TCE-contaminated wastes, waste solvents, undewatered industrial sludge, fuels and oils, and sodium valves from aircraft engines. From water level measurements taken in monitoring wells in Area D, the groundwater in this area seems to be moving to the west, probably in response to localized off-base pumping, and the local gradient is about 6 times greater than the subregional gradient at the Base.

It is possible that localized steeper shallow groundwater gradients as well as the unknown thickness and characteristics of the shallow aquifer off Base could increase the groundwater velocity as much as three times. With a decrease in aquifer thickness to about 1 foot and

steepening of the gradient to about 2 percent, the velocity of the water in the shallow sands zone would be about 25 feet per year, assuming the porosity remains the same. In places on the Base, the shallow sands have been about 1 foot thick, and a 2 percent gradient is reasonable near producing groundwater wells.

Disposal practices along the Base boundaries over the past 40 years therefore could have resulted in migration of shallow groundwater contaminants off Base at a rate of 25 feet per year. However, some of the off-base contaminated wells are located at distances greater than 1,000 feet from the Base boundaries. The data collected on the Base during the Phase II Installation Restoration Program do not allow a determination of whether private or public wells located at distances greater than 1,000 feet off Base have been contaminated by past Base disposal practices. It should be noted that the areas southwest and west of the Base contain numerous light industries of types that traditionally have used the kinds of solvents that have been found in the off-base wells.

FIELD TESTING

This section presents results from certain field testing activities which included establishing the location of Base well 7 and logging specific conductance and temperature for selected monitoring wells.

Locating Base Well 7

The foundation of the well house surrounding BW7 was located using a magnetic flux indicator. The inside of the building was excavated and the well head was located in the building basement. A weighted line lowered into the well met refusal at a depth of 80 feet. Rotary-wash drilling was employed for cleaning out the well. After the well was cleared to 60 feet, the drill encountered a coarse mixture of sand and clay. Both 8-inch and 4-inch drill bits met refusal at 80 feet. The well log for this well shows that it was gravel packed for its entire length of 80 feet.

Specific Conductance and Temperature Logging

Results showing specific conductance and temperature readings taken in the field are presented in Table 4.20. Three Base monitoring wells

(MW4, MW6, and MW7) and four Stage I monitoring wells (MW19S, MW19D, MW26S, and MW26D) were tested. Temperature readings were constant (20 to 21°C) for all of the wells, both shallow and deep. Specific conductance varied irregularly with well depth. However, the fluctuation within each well was minimal (<7 percent) relative to the mean difference between wells. A noticeable difference in specific conductance occurs between shallow and deep wells at the same locations (i.e., MW19S in relation to MW19D, and MW26S in relation MW26D). Mean conductance values for wells 19S and 26S, respectively, are 403 μ mho and 527 μ mho, where the deep wells (MW19D and MW26D) show respective conductance readings of 240 μ mho and 211 μ mho. Clearly, two separate aquifers have been identified, with the shallow zone exhibiting more total dissolved solids than the deeper zone. This finding is consistent with analytical data. The deeper groundwater aquifer is "cleaner" than the shallow one. As indicated by specific conductance, the concentration of inorganic constituents (salts) present in the shallow wells is about twice the concentration in the deeper wells.

PROBLEM DEFINITION

Plume Identification

Groundwater samples from all wells on the Base were analyzed for selected organic and inorganic constituents. The shallow wells (completed into the first sands) show the presence of constituents particularly along the western border of the Base, where former disposal sites existed. However, the data also show organic compounds and trace metals in shallow wells throughout the Base; often, these wells were not located near a known disposal area (i.e., MW29S, MW30, and MW31). Chemical constituents entering a groundwater system from a specific single source often migrate as a plume with semi-defined boundaries. The highest constituent concentrations within the plume tend to exist near the source area, with concentrations decreasing downgradient as dilution takes place.

TABLE 4.20 SPECIFIC CONDUCTANCE AND TEMPERATURE IN SELECTED MONITORING WELLS

Well No.	Testing Date	Depth (feet)	Temperature (°C)	Specific Conductance (µ mho)	Mean Conductance (µ mho)
MW4	9/24/82	110	21	320	
		110ª	21	358	358 <u>+</u> 27
		125	21	382	_
		Bottom of well	21	372	
MW6	9/23/82	∿90	20.5	285	
		100	20.5	265	266 <u>+</u> 13
		110	20.5	260	_
		Bottom of well	20	255	
MW7	9/24/82	95	20	243	
		105 120 ^b	20	239	240 + 2
		120 ⁵	20	239	-
MW198	9/24/82	85_	20	395	
		85ª	20	410	
		100	20	399	403 + 6
		120	20	405	_
		Bottom of wel	1 20	405	
MW 19D	9/24/82	85	20	242	
		100	20	238	
		120	20	238	240 + 2
		140	20	240	-
		Bottom of wel	1 20	241	
W265	9/24/82	100	21	540	
		115	21	530	527 + 15
		Bottom of wel		510	• •
MW26D	9/24/82	100	21	209	
		120	21	212	211 + 2
			21	213	
		140 160	21	210	

a Duplicate test b Bottom of well

Attempts to delineate plumes of constituents migrating from individual disposal sites at McClellan AFB have been complicated by the detection of constituents at unaccountable concentrations and locations across the Base. Figures 4.1 and 4.2 depict the varying concentrations of TCE detected in monitoring wells on successive sampling dates. These data indicate an attenuation of concentrations occurring in no definite pattern in relation to time or area. The occurrence of constituents in wells with no apparent source indicates that accurate delineation of plumes from individual site locations may not be possible.

Since there appear to be multiple sources for the constituents identified, and the source materials were emplaced at different times, migration would be likely to occur at unpredictable time intervals. In addition, groundwater levels in the upper sands zone vary seasonally, so constituents from some sites may have been solubilized from soil in a fluctuating sequence. Another factor that inhibits tracing groundwater constituents back to a specific source is that, in many cases, groundwater has flowed beneath several sites, picking up constituents from one or more areas. Also, past waste management practices may have resulted in the deposit of materials in areas not identified during Phase I of the IRP.

It is possible that chemical constituents may be identified in downgradient areas off the Base. The interface between areas containing detectable constituents and those areas which do not could delineate the leading edge of a plume. Phase II of the IRP did not provide for any off-base activity so off-base plume movement was only estimated.

Effects on Base Water Supply Wells

Since most Base production wells were constructed in such a way that gravel packs or casing perforations exist in the first sands zone, a potential problem exists with the on-base water supply wells. Constituents in the water in the first sands could migrate through the well gravel packs causing potential quality problems in the Base water supply.

The deeper aquifers show constituents to be near or below limits of detection, except pesticides and herbicides. Deep well MW19D, located

in the sludge pit area, clearly shows an absence of constituents, even though it is situated in an area exhibiting "worst case" conditions. Well 38D, located west of the sludge pit, contained low levels of constituents. This well was located immediately adjacent to and downgradient from Area D, which has shown the highest level of groundwater contamination. During well installation, the shallow groundwater was encountered, and would be expected to mix during drilling with deeperlying water in the second sands; there is thus the probability of cross-contamination. Additional samplings of MW38D would provide data on the actual water quality in the second sands. In general, the deeper sands appear to contain no EPA priority organic pollutants; the absence of constituents is consistent at all well locations on the Base. Consecutive samplings of these deeper wells (MW16D through MW29D and MW38D) should further reinforce this finding.

Selected analyses of wells showed negative results in most cases. PCB analyses of groundwater samples from all wells installed on the Base during Stages I and II resulted in non-detectable concentrations. Cyanide was found in seven wells on the Base, mostly at or near detection limits except for MW29S. Cyanide was also detected in MW16S located at the extreme northern (upgradient) Base boundary. Cresylic acid was detected in a shallow well placed between the suspected source (Building 475) and Base production well 7 (abandoned). Two wells (shallow and deep) placed further downgradient from production well 7 did not contain cresylic acid. Aliphatic material (grease and oil) appeared at elevated concentrations in one well (MW20S) along the western edge of the Base. This material has not reached the second aquifer but has migrated in a southerly direction. Detectable concentrations of grease and oil were found in a shallow well (MW33S) located due south of MW20S.

The presence of herbicides and pesticides in all of the shallow wells and most of the deeper wells is universal across the Base. Concentrations vary from one well location to another, and from one sampling to the next within the same well. The actual appearance of a particular compound does not follow a consistent pattern, with one sampling often showing a compound that is not detected during a subsequent sampling event. The evidence indicates that, to some degree,

herbicides and pesticides are being contributed to on-base groundwater from off-base sources. The source of these constituents in the groundwater also may be partially from Base application and/or disposal. However, monitoring wells 16 and 17, both at the extreme northern (upgradient) end of the Base, show the presence of herbicides and pesticides in the shallow and deeper aquifers. The source of groundwater for both wells is off-base from the north. Historical records do show that two off-base production wells north of the Base contain 2,4,5-TP (Silvex). The occurrence of these herbicides and pesticides appears to be ubiquitous.

A general range of constituent concentrations detected in all on-base shallow wells is compiled in Table 4.21. These data reflect results only for constituents present at measurable levels in at least one groundwater sample. Analytical reports which present comprehensive results for all constituent analyses performed are contained in the appendices. Values lower than the detection limits were not used to calculate the range of concentration except for those constituents found above detection limits in only one or two shallow groundwater samples. For these constituents, it was not possible to tabulate low and/or median concentrations representing measurable quantities. In these instances, trace level data and "not detected" results were used to establish the range of concentration. The source areas in which the high concentrations were found are noted in the table.

All three soil borings beneath the industrial waste line contained trace metals at both the 15 and 20-foot depths, including high levels of arsenic and selenium.

Effects on Off-Base Water Supply

The physical characteristics of the shallow sands zone are summarized on Table 4.22. The Base is underlain by a shallow aquifer of thicknesses varying from 1 foot to 17 feet; the aquifer may be discontinuous in places. Permeabilities range from 0.8 gpd/ft² to 4.2 gpd/ft², and transmissibilities range from 4.7 to 21 gpd per foot. The groundwater in this zone moves in a south-southwesterly direction but is influenced locally primarily by off-base production wells. Based on physical characteristics, it appears that groundwater velocity is about

TABLE 4.21

PANGE OF CONSTITUENT CONCENTRATIONS DETECTED IN BASE MONITORING WELLS STAGE I AND IL SHALLOW WELLS

	1	Minimum				
Constituent	Meagurement	Level	Source Area	4013	Concentration	
			An III an Inox	5. TC	704	ned) an
Volatiles						
Denzene	ądd	10.0	•	989	9	5
carbon tetrachloride	qdd	٦.0	4	25	ON	91,
chloroform	qdd	-:	9	120		90
1,1-dichloroethane	qdd	-:	٥	250	· <u>•</u>	2 5
1,2-dichloroethane	2	1.0	. c	:	. 1	2 1
1,1-dichloroethylene	400		۵ د	***	€,	
1.2-trans-dichloroethylene	1	: -	.	22.00	n ·	2,500
athelbentene		: .		700	ø	2
methylene chlorita	add	•		330	9	¢10
Merny Lene Chick Lde	qdd.	• ·	٥	5,000	1,000	3,000
retrachioroethylene	qdd	<u>-</u>	۵	70	'n	18
toluene	qdd	- -	C-1	440	so.	20
1, 1, 1-trichloroethene	qdd	٠.٥	۵	12,000		יייי י
trichloroethylene	qdd	1.0	٥	14, 100	48.6	.,
trichlorofluoromethane	qdd	7.0	٥			5 2
vinyl chloride	ą.	- -	. 0	. 9	È <u>e</u>	2
				}	2	2
Acid Compounds						
2, 4-dimethylphenol	qdd	0.1	۵	76	9	9
pentachlorophenol	qdd	0.1	088	260) va	: 5
phenol	qdd	10.0	٥	400	95	2 5
;					•	•
Base/Neutral Compounds			٠			
anthracene	qdd	٠.	C-1	220	Q	410
bis(2-ethylhexyl)phthalate	qdd	-0.	υ	230	÷ •	20
1,2-dichlorobenzene	qdd	٠.	a	100	21	: 2
1, 3-dichlorobenzene	qdd	1.0	٩	88	=	
1, 4-dichlorobenzene	qdd	0.2	۵	9	: 5	;
di-n-butyl phthalate	qđđ	1.0	- -5		2	: 5
fluorene	qdd	-:	C-1	06	3	Î
naphthalene	qdd	-0.	C-1	6	010	£ %
1, 2, 4-trichlorobenzene	qdd	. .	۵	12	•	.
Pest (c) des/Herb) c) des						
Aldrin	402	100.0	6		•	
alpha-B#C	400		۰ د	6.6	0.00	0.503
Det a - BHC	ndid.	700.0	< :	eo.	0.018	0.032
CXE-47/40		90.0		0.142	0.007	0.048
	ndd.	****		0.83	0.025	990.0
2 4-5	<u>.</u>	0.002		2.76	0.002	0.038
, ,	gd.	0.001	C-3	95.0	0.003	0.063
	g dd	0.001	1-0	0.087	0.003	0.005
A O TEN (SILVEX)	qdd	0.002	Q	0.36	0.004	0.051
	qdd	900.0	۵	0.20	40.00€	40·00e

TABLE 4.21 (Continued)

	1	Minimum		•		
Constituent	Measurement	Level	Source Area	H19h	Lov	Median
endonulfan mulfate	qdd	0.03	o .	0.011	(0.03	<0.03
heptachlor	qdd	0.003	DEB	0.88	0.013	0.056
heptachlor spoxide	qdd	0.004	198	0.17	0.007	0.027
Motals						
ant imony	m 9/1	0.005	a	90.0	900.0	0.008
arsenic	mg/1	0.08	a	0.66	0.24	0.30
cadmium	#9/1	0.0	UIA	0.08	0.01	0.014
chronium	mg/1	0.05	۵	4.17	0.07	0.12
comber	m g/1	0.05	۵	1.18	0.12	0.33
lead	1/6	0.01	<	0.98	0.01	0.033
mercury	a 9/1	0.0005	080	0.0027	0.0005	0.0012
nickel	m 9/1	0.05	UIA	2.13	0.05	0.08
selenium	1/6	0.01	۵	0.355	0.01	0.049
zinc	mg/1	0.02	990	1.4	0.02	0.07
Selected Analyses						
cresylic acid (Cresol)	1/6 1	so	<	36	Ç	
cyanide	# 9/1	0.03	VI0	0.95	0.03	0.03

a List of constituents excludes those which were not detected in any shallow groundwater sample. A total of 77 constituents were tested and not found above detection limits. Comprahensive results for all analyses performed are contained in Appendices K, L, and M.

Area in which high concentration was detected:

A - Area A C - Area C

C-1 - Subarea C-1 C-2 - Subarea C-2

D - Area D
DBB - Downgradient Base Boundary
UBB - Upgradient Base Boundary
UIA - Upgradient Base Industrial Area
C MD - Not detected
d W - Analyses were performed for only two shallow groundwater samples.

TABLE 4.22
PHYSICAL CHARACTERISTICS
OF THE SHALLOW SANDS ZONE

Parameter	Value
Thickness	1 foot - 17 feet
Transmissibility	4.7 gpd/ft - 21 gpd/ft
Permeability	0.8 gpd/ft ² - 4.2 gpd/ft ²
Velocity of groundwater	8 ft/year - 25 ft/year a

a The higher value reflects groundwater velocity influenced by local pumping and varying thicknesses.

8 feet per year, with the possibility of velocities of 25 ft/year in cases where the gradient is influenced by local pumping and changing aquifer characteristics; higher velocities would be possible if the aquifer material were dramatically different from what has been observed, i.e., old stream channel deposits with high permeability. Deeper aquifers exist, disconnected from the shallow aquifer and separated by at least 20 feet of predominately fine-grained material.

Since off-base wells may have been constructed with gravel packs and perforations in the shallow sands zone, constituents in groundwater (that could be the result of past McClellan AFB waste disposal practices) could migrate downward into lower aquifers causing quality problems with off-base water supply wells. Sufficient time has passed since the disposal of waste material on McClellan property for constituents in the first sands beneath the Base to cause problems in public and private water supply wells.

Source Areas

Based upon analytical data from groundwater monitoring wells, the correlation between wells and associated disposal sites and clusters was examined. Perceived correlations are summarized on Table 4.23. Very little definite information exists as to contents of these sites. As can be seen from the table, twenty-one sites could have direct effects on groundwater. The other twenty-five sites were not identified as causing groundwater degradation but remain as potential sources of

TABLE 4.23

SUMMARY OF DISPOSAL/STORAGE SITES
AND CURRENT PERCEIVED STATUS

Has the Site Affected Groundwater?	Site Designation
Yes ^a	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 25, 26, 27, 30, 36, 37, 38, 40, 41, 42, 43
Not identified ^b	1, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 28, 29, 31, 32, 33, 34, 35, 39, 44, 45

a Site was located upgradient from affected wells.

groundwater quality problems. There are two types of material that can be causing potential problems. These are the disposed material and underlying site soils. Where constituents have migrated from disposed material into groundwater, the underlying site soils may have been contaminated. Both of these affected materials may pose groundwater quality problems through continued discharge.

Summary

Past waste disposal practices at McClellan AFB have resulted in three main areas of concern under the IRP. These are (1) affected materials (waste and soils), (2) on-base water supply, and (3) off-base water supply. The groundwater affected by past disposal activities appears to be primarily limited to the shallow sands zone. Based on estimated groundwater velocities and aquifer characteristics, constituents in groundwater on the Base have migrated outside Base boundaries, causing contamination of off-base private and public wells within a radius of 1,000 feet. Further off-base field work would be required to determine if migration of constituents could have occurred at greater distances from the Base. The limitations on how far the groundwater may travel are related to the fact that the Sacramento region is a closed basin due to overdrafting of the groundwater resources. A groundwater

b No evidence exists to document that the site is causing groundwater quality problems; however, future monitoring may change results.

trough exists around the City of Sacramento (see Figure 2.3); ground-water thus would flow toward this trough from the aquifers being tapped for water supply. It is unknown if the shallow groundwater encountered at McClellan AFB would follow the regional groundwater movement trend. If it did not move toward the groundwater trough, it would continue moving downgradient within the Victor Formation which surfaces along the Sacramento River.

SECTION 5

EVALUATION OF ALTERNATIVE MEASURES

CHAPTER 5

EVALUATION OF ALTERNATIVE MEASURES

In general, environmental concerns identified during field programs and past investigations at McClellan AFB focus on affected material, on-base water supply, and off-base water supply. A discussion of potentially applicable measures to address these concerns is presented in this chapter. The first part of the discussion provides a general overview of the alternatives that could be applicable to the situation at McClellan AFB. The second part of this chapter discusses the application of the alternatives to the three major problems.

OVERVIEW OF ALTERNATIVES

Alternative Measures for Affected Materials

Excavation

The most direct approach to eliminating affected materials involves excavation. The removed material can be hauled to an existing secure site off Base and the excavation can be refilled and/or regraded. When the quantities of excavated materials are relatively small, haul and replacement can be feasible. If large quantities of material must be managed or secure disposal sites are not conveniently located, then on-site treatment and replacement of excavated material can be a viable alternative. Another alternative would be to develop a secure landfill on Base. Management techniques for affected materials are discussed in the following paragraphs.

Management of Excavated Materials

Off-Base Landfill. Excavated material can be disposed at existing landfills. If the material to be removed is considered to be hazardous waste then disposal at a Class I or Class II-1 site may be necessary.

The two closest facilities of this type, owned by IT, are located at Benecia (Class I) and Montezuma Hills (Class II-1), about 80 and 50 miles away from McClellan AFB, respectively. Transport of large volumes of material to these facilities will require a major hauling operation at high costs over a long period of time.

In addition, there is a shortage of hazardous waste landfill capacity in California. Deposition of large volumes of soil material in these sites will reduce their capacity to handle waste loadings from current operations. Later in this chapter in the discussion entitled "On-Base Affected Materials", the volume of disposed material and affected soils is estimated to be 70,790,000 cubic feet or 2,622,000 cubic yards. This volume is more than half the available secure landfill capacity in northern California, which has been estimated to be approximately four million cubic yards.

Since several sites may contain soil materials with constituent levels that could necessitate removal to depths reaching groundwater, excavation may pose a significant problem. Removal of materials to depths reaching 80 or 100 feet may be extremely difficult to accomplish. At best, removal of material to these depths will be extremely expensive even if technically feasible.

On-Base Landfill. The design and construction of a secure hazardous waste site on Base would be an alternative to off-site transport of material or treatment and replacement of material. The landfill would have to meet RCRA standards and would require permits from several state agencies. Included would be a hazardous waste facility permit from the state health services department and waste discharge requirements from the regional water quality control board. After construction of an approved facility, affected material removed during excavation would be placed there for permanent disposal.

One advantage of this alternative is that it may be possible during permitting to arrange to dispose of McClellan's operational hazardous waste at such a site.

Heat Treatment. Chemical constituents that are mostly organics, particularly readily volatile organics like solvents, may be converted to gases by application of heat. A possible way to accomplish this would be by placing excavated materials in a rotary-kiln type dryer that would heat the solid material to a temperature that is needed to remove the volatiles. The resultant gases could be ignited to destroy the organics, using supplemental fuels.

If the affected materials vaporize at low temperature, and if these affected materials constitute a relatively small fraction of the total material mass, thin layers of material may be applied on ground surfaces to utilize solar heat to volatilize the constituents. This process results in hydrocarbon emissions to the atmosphere which may require air pollution control measures. The major limitation of heat treatment is that it is only effective for organic constituents.

Extraction with Solvents. Constituents may also be removed by leaching affected materials with suitable solubilizing or chelating agents. Leaching may be accomplished by mixing an appropriate solvent with the material mass and draining the resulting solution from the mixture either by gravity or by the use of vacuum-type filters. spent solvent could then be recovered using distillation or exchange processes. Recovered solvent may be returned to the solid material for additional passes until the desired level of constituent removal is Depending on the type of solvent used, it may be necessary before replacement to cleanse the remaining solvent in the affected material with water. Because of water solubility, certain alcohols may be suitable as a solvent for removing many organic substances. metals may be removed from affected materials with the use of strong chelating agents such as EDTA. The final choice of solvent and removal system would depend largely on the specific natures of the particular materials to be treated. This type of operation has not yet been done on a large scale.

Microbial Decomposition. It may be possible to use microorganisms to treat affected materials. Organisms are often used to metabolize constituents for treatment of dilute solutions of liquid industrial wastes. Oil refinery wastes are commonly treated by landfarming in

5-3

which the wastes are plowed into soil surfaces where aerobic conditions and viable cultures of organisms are maintained. Microbes suited to this environment then metabolize the organic constituents into innocuous constituents. Microbial degradation may be enhanced by addition of moisture, trace materials, and/or a nutrient source. Such systems are used in the ridge-and-furrow composting of wastewater sludges.

The major limitation of microbial decomposition is that it is only effective for organic constituents.

<u>Fixation</u>. Fixation can be used to immobilize constituents by altering the physical state of the affected materials. This is usually accomplished by the addition of chemical agents to affected materials to produce a final product resembling weak concrete. A number of commercial fixation processes are currently available. Fixation technology is most often used to solidify liquid wastes so that, when water contacts the affected material, constituents are not mobilized.

Fixants typically used are cement, lime, fly ash, and other solidifying materials. It is sometimes necessary to add soil in addition to the fixatives to make the weak concrete. These processes are particularly effective when the constituents are inorganic in nature, such as plating wastes. However, commercial processes are available for organic materials.

Although unproven technology, materials containing organic constituents could possibly be fixed by addition of a small amount of asphaltic material. Both hot asphalts and emulsified asphalts might serve this purpose.

Site Closure

Closure of disposal sites, land treatment facilities, and storage areas (when no longer used) to meet Resource Conservation and Recovery Act (RCRA) requirements may be a desired alternative. In most cases proper closure will be in a manner to comply with Section 267.10 of RCRA for facilities in operation after 1976. For each individual site the exact closure requirements and procedures will reflect the type of site, the nature and amount of waste, location and topography, and geological and soil profiles as well as other considerations that must

be evaluated. Under certain conditions closure may include the implementation of a groundwater monitoring program.

In Situ Management of Affected Materials

Several of the treatment methods that were discussed for excavated materials could be used on an in situ basis by leaving the material in the ground and altering its chemical or physical properties. These methods include heat treatment (air stripping), solvent extraction, microbial degradation, and fixation. In situ treatment requires bringing the treating or fixing agent into contact with the material in the voids of its physical structure. This contact is ordinarily brought about by either pressure injection or gravity percolation of the treating agent. If solvents are introduced to "cleanse" in-place materials then the resulting solution may have to be removed from the ground and treated.

<u>Percolation</u>. Percolation is the process through which fluid materials are introduced into solid material by gravity flow. A percolation pond could be constructed on the surface to introduce solvents or fixation materials into the underlying soils through a series of wells.

<u>Injection</u>. Solvents or fixants can be introduced using injection techniques through wells. Injection has been used to isolate waters or problem wastes to deep aquifers where the intervening materials will not permit percolation by gravity. In practical applications the aquifers are generally very permeable and the injection head is usually only the depth of the well.

It is possible to increase the pressure on an injection well to increase the flow into the well. However, there are physical limits on the amount of pressure that can be applied. Since soil density is typically about twice that of water, a cavity will be formed and upheaval may occur at the surface if the pressure head is increased to more than twice the depth to the point of injection. The ability to inject fluids into soil is highly dependent on soil permeability.

Gas Injection. It may be possible to inject ambient air, heated air, or other gases into unsaturated soils and materials. The gas would return to the surface carrying with it volatile organic materials.

Where the constituents are volatile organics this may be a viable solution.

If air pollution associated with the materials flowing out of the ground presents a problem, it may be necessary to operate the system in reverse, using vacuum pumps to draw air into the wells. The contaminated air could then be treated, probably with activated carbon or other cleansing units.

Gas scrubbing of constituents from solid material is untried and untested technology. Should such a system be contemplated considerable predesign research and testing will be required. The major drawback of this system is that it is only effective on organic constituents.

Capping. One method of material management is to leave the material in place and cover affected surface areas with an impermeable seal. The material used for the seal could be clay, cement, asphalt, or other material of that nature. Caps are constructed to be sloped in such a manner so that rainfall is diverted away from the site and is not permitted to recharge through affected material. In this way the site is sealed from intrusion of surface water.

Alternative Measures for Affected Groundwater

Where a contaminated groundwater pool exists the options are to (1) remove the affected water, or (2) isolate the affected water and its constituents to prevent continued migration to unaffected areas.

Removal of Affected Water

The removal of constituents from groundwater is dependent on the ability to pump or drain the aquifer. It might be possible to drain the aquifer by installing an artificial drain perpendicular to the aquifer. This could be accomplished by excavating past the aquifer and then installing gravel and a pipe in the trench. The pipe would terminate in a sump or sumps which could be pumped intermittently. The depth below surface for which this method is effective is limited to current trenching techniques.

Another method of removal of affected water is by installation of a series of withdrawal wells. The wells are installed and perforated at depths that will provide for removal of affected water zones. The distance between wells is based on local hydrogeological conditions. Good producing water zones are necessary for this system to be effective.

Alternately, it may be possible to excavate several deep holes to the groundwater level and install a Ranney collector system. In this system a machine could be lowered into the holes and perforated pipe could then be jacked horizontally to provide the required drainage. This technology is used to jack pipes under highways and other structures for drainage and for tapping water sources below surface water bodies; it is expected that such jacking could force a drainage pipe up to 500 feet into an aquifer.

Isolation of Affected Groundwater

It may be possible to contain affected groundwater under a site or group of sites by surrounding the groundwater with slurry walls, generally constructed of clayey material. Coupled with capping the surface to prevent infiltration, this technique could effectively isolate problem areas. Depending upon the depth to groundwater, extensive excavation could be required to install the slurry walls. The placement of slurry walls hydraulically by injection is possible in certain situations, depending upon soil permeabilities. The use of slurry walls is not recommended for isolation of sites containing plating wastes or other low/high pH waste material as caustic materials tend to destroy the integrity of clay barriers.

The affected waters might also be effectively isolated by injection of water through wells located around a site or an area to create a "mounding" effect. This system requires that the soil material be highly permeable so that an effective mound can be created.

Treatment of Affected Groundwater

When the water removed from an aquifer contains constituents that negate its direct discharge to receiving water bodies, some type of treatment may be necessary. If only volatile organics are present in small quantities, the treatment might consist only of spraying the water

into the air while watering the landscape to permit the organics to volatilize. Activated carbon treatment along with coagulation/flocculation (for trace metal removal) in small package units might be used to treat the affected water. Air stripping may be used in tandem with activated carbon for organic removal. The removal of organics by air stripping tends to extend the operational life of carbon. A drawback of air stripping is the air pollution problem that could be created.

Alternative Measures for Industrial Waste Line Remediation

To minimize the amount of water that is transferred from the surface to the first sands zone, the leaking industrial waste line can be rehabilitated or replaced. The technologies involved in these endeavors are those that are routine and common practices. Included in these alternatives are: (1) repair the line in place by pressure grouting; (2) locate leaks and replace sections by excavation; (3) thread plastic pipe sleeve through the existing line; and (4) install a new line next to the existing problem line.

Pressure Grouting

In this procedure, the leaks are located by means of video camera inspection or by localized air testing procedures. Once located, the defective sections of the line can be repaired by pressure grouting from the inside with a chemical sealant. The sealant is solidified by a catalyst after being forced into the leak.

Excavation

In this procedure, after the leaks have been located, the trench is re-excavated and the leaking sections or joints are replaced. This is accomplished by using a plain-end type of coupling to secure the new pipe lengths to the adjacent sections that are still in place.

Pipe Sleeving

In this procedure, a suitable type of plastic pipe is threaded into the existing pipe to provide a secure conduit for transporting the liquid. The existing pipe provides the structural capability and the interior threaded sleeve provides the hydraulic integrity.

Installation of New Line

When the existing line is determined to have numerous leaks or is badly deteriorated, it may be the most cost-effective solution to abandon the line and construct a new line to provide reliable capability.

ON-BASE AFFECTED MATERIALS

Problem Definition

The assumption throughout Phases I and II of the IRP has been that past Base disposal practices could be affecting groundwater quality. Materials that could affect the groundwater as a result of disposal practices include materials disposed, as well as the soil column underlying the disposal/storage sites to the depth of the shallow groundwater. The soil column may have been affected by the downward migration of constituents from the disposal area as was graphically illustrated on Figure 2.6. The affected materials could constitute a continued source of potential groundwater quality problems.

Affected Sites

Forty-six disposal/storage sites have been identified on the Base. During the Phase II field program, menitoring wells were installed downgradient from some of the past disposal sites. On the basis of the presence or absence of constituents identified in those wells, the 46 sites have been evaluated according to their identified contribution to groundwater problems. These site evaluations were presented on . These site evaluations were presented on . These site evaluations were presented on . These sites evaluations were presented on . The sites evaluations evaluation

For each of the 21 sites identified as affecting groundwater quality, the estimated volume of disposed material as well as the estimated volume of the affected soil column from ground surface to the shallow groundwater are presented in Table 5.1. Similar information is presented in Table 5.2 for those sites not identified to be affecting groundwater quality. The sites that have been assumed to affect the shallow groundwater comprise over 14 million cubic feet of disposed material, and the affected soil column would constitute over 56 million cubic feet of material. It should be noted that these volumes are only gross estimations; actual volumes may vary significantly. The estimated

TABLE 5.1

ESTIMATED VOLUME OF AFFECTED MATERIALS
AT SITES AFFECTING GROUNDWATER QUALITY
MCCLELLAN AFB, CALIFORNIA

Area	Disposal/Storage Site Affecting Groundwater Quality	Estimated Volume of Disposed Material (1,000's cu ft)	Estimated Volume of Affected Soils (1,000's cu ft)
A			
	25	3,000	12,500
	37	•	10,000
	38	**	**
	40 Area A Total	3, <u>240</u>	3,800 17,300
В			
	30	97	4,000
	36	***	***
	Area B Total	97	4,000
C-1			
	41	2,000	9,000
	42	1,200	5,000
	43	1,100	4,400
	Subarea C-1 T	otal 4,300	18,400
C-2			
	7	600	1,600
	8	500	1,300
	9	600	1,600
	10	600	1,600
	11	600	1,600
	Subares C-2 T	otal 2,900	7,700
D	2	600	1,600
	3	600	1,600
	4	600	1,600
	5	600	1,600
	6	500	1,300
	26	600	1,600
	27 Area D Total	0.4 3,500.4	$\frac{3}{9,303}$
	BASE TOTAL	14,087.4	56,703

^{*} Material removed (see Table 2.1).

^{**} Site is Building 475.

^{***} Site is storage area.

TABLE 5.2

ESTIMATED VOLUME OF AFFECTED MATERIALS AT SITES NOT IDENTIFIED TO BE AFFECTING GROUNDWATER QUALITY MCCLELLAN AFB, CALIFORNIA

Area	Disposal/Storage Site Not Identified to be Affecting Groundwater Quality	Estimated Volume of Disposed Material (1,000's cu ft)	Estimated Volume of Affected Soils (1,000's cu ft)
A	20	2 404	
	39 Area A T	3,000 Otal 3,000	8,000 8,000
В			
	35	<u>•</u>	3,000
	Area B T	Cotal 0	3,000
C-1	17	600	1,600
	18	600	1,600
	19	600	1,600
	20	1,500	3,800
	21	1,700	4,400
	22	2,000	3,200
	28 32	4,000	3,200
	Subarea C-1 T	51 Otal 11,051	2,000 21,400
C-2	12	600	1,600
	13	600	1,600
	14	600	1,600
	15	0.4	3
	16	0.4	3
	Subarea C-2	Total 1,800.8	4,806
D	1	2,000	5,000
	33	400	7,000
	Area D tota	2,400	12,000
Isolated			
	24	1,500	4,000
	29	80	3,200
	31	400	3,200
	34	80	3,100
	45 46	450 **	7,200
	* =	s Total 2,510	20,700
	BASE TOTAL	20,761.8	69,906

^{*} Material removed (see Table 2.1).

^{**} Affected material has been excavated and transported to approved site.

volume of affected soils reflects the amount of material that is present beneath each site down to the water table. Actual excavation would entail removal of significantly more material. Excavation to the depths that might be necessary would require removal of significant amounts of soil from sidewalls.

Alternative Corrective Measures

To eliminate potential sources of groundwater contamination, a number of alternative options are available. Table 5.3 lists these alternatives along with equipment requirements, identified short and long-term impacts, and the advantages and disadvantages associated with each alternative measure. That generic summary delineates options available for affected material management. The alternatives that entail in situ treatment do not appear practical for the particular geologic regime underlying McClellan AFB.

For injection of a fixant into either the soils above the shallow groundwater or into the aquifer material itself, the limiting conditions would be the permeability of these materials and the corresponding pressure that would need to be applied to inject the fixant. Based on the permeability determined from field test results, injection wells would need to be placed at such close distances to each other as to make this system impractical (i.e., about one foot apart). Further discussion is contained in Appendix T.

Since the geology of the area effectively limits the treatment of affected materials in place, alternatives that can be considered include excavation to remove the material from the ground as well as capping the sites to isolate them from surface water intrusion. Table 5.4 identifies the alternative technologies potentially applicable to each site. Since no samples were taken of site materials in this project the application of the different management techniques is based upon background information summarized in Table 2.1.

It should be kept in mind that removal of affected soils would have no effect upon the shallow groundwater which currently contains identified chemical constituents. This shallow groundwater would continue to move downgradient and off the Base.

TABLE 5.3

ALTERNATIVE CORRECTIVE MEASURES POR AFFECTED NATERIALS MCCELLAN AFB, CALIFORNIA

Measure	Description	Hajor Required Equipment	Required Long-Term Operations	Short-Term Impacts	Long-Term Impacts	Adventages	Disadvantages
Endill	Excavate affected sites to shallow groundwater. Adquire fill material to replace removed solls. Transport material to approved off-site hazardous waste landfill.	- Excavation equipment - Hauling trucks - Fill material	Mone	Generation of truck trips firm Base to landfill over years . Local noise and air pollution problems caused by truck traffic . Air pollution problems caused by excavation . Disruption to localized areas from excavation	Elimination of hazardous waste landfills in area	Removal of constituent source	Extensive excavation Reduce lifetime of approved hazardous waste landfills in area Existing contaminated aballow groundwater would remain
Excevation/ On-Base Jandfill	Design and develop secure hazardous waste lanifill on Base. Obtain permits from state and local agencies. Excavate affected sites to shallow groundwater. Acquire fill material to replace removed soils. Transport material to onbase hazardous waster lanifill.	. On-base landfill . Excavation equipment . Conveyor/hauling aystem . Fill material	Inspection and monitoring of landfill	Air pollution problems caused by excavation . Disruption to localized areas from excavation	Consolidation of material into one secure site area	. Removal of constituent source material . No material sent to area hazardous waste landfills	Extensive excavation Excavation Excavated material is atill on Base Existing contaminated shallow groundwater would remain

TABLE 5.3 (Continued)

Measure	Description	Na jor Naguirad Equi pme nt	Required Long-Term Operations	Short-Term Impacts	Long-Term Impacts	Advantages	Disadvantages
Encavation/Heat Treatment	Excavate affected aits. Heat the material in rotary kiln to remove volatiles and replace material (additional fill) may be necessary).	. Excavation equipment . Conveyor system . Potary kiln equipment	None	. Disruption to localized areas from excevation . Air pollution problems caused by excevation	Metale would remain available within the soil for potential migration into groundwater	Organics would be removed from material	Extensive excavation only organica are removed; metals remain in material . Affected shallow groundwater would remain
Excavation/ Extraction with Solvents	Excavate material and place within concrete-lined containment areas; if material containment areas; if material containment areas; leaching with ethyl alcohol is possible. Removal of metals could be by atrong chelating agent (EDTA). Determine operational requirements for solvents by field testing.	. Excavation equipment . Conveyor system . Leaching fluids . Leaching fluids . Leaching and treatment system	Non e	. Disruption to localised areas from excavation and leaching operation . Air pollution problems caused by excavation	Removal of contaminant sources to groundwater	Removel of conteminants from material	. Extensive excevation . Residual leaching water requires treatment . Affected groundwater would remain . Not a proven technology

TABLE 5.3 (Continued)

Messure	Description	Hajor Required Rquipment	Required Long-Term Operations	Short-Term Impacts	Long-Term Impacte	Advantages	Disadvantages
Ercavation/ Microbial Decomposition	Excevate affected aites. Place material on concrete-lined containment areas. His microorganisms that were devel- oped for specific wastes with this material. Additional fill	Excavation equipment Conveyor system Strain of microorganisms developed for specific vaste requirements Contact areas	None	. Disruption to localized area from accavation . Air pollution problems caused by excavation	Metale would remain in material	Organics would be removed from material	Extensive excevation meaning shallow groundwater available for flow off Base Hetals would reseal in saterial . Not a proven technology
Excevation/ Fixation	Excevete affected sites. Treat the exceveted material and replace ma- terial in site.	Excavation equipment Conveyor system Fixation material and equipment	Mone	. Disruption to localized areas from excavation . Air pollution problems caused by excavation	Elimination of source material for shallow groundwater contamination	Maste and soil materials are made inset, thereby eliminating ahallow groundwater contemination sources	vation vation Pemaining shallow groundwater available for flow off Base
Capping	Inspect site area to determine if cap is required. If necessary determine the appropriate material to be used. Grade area to drain water from site. Install cap.	. Paving/grading equipment . Asphalt, concrete, clay, etc.	Inspection of cap integrity	Distruption to localized areas from grading operations	Prevention of aurface water from contacting waste material	Prevent additional leachate from being generated by surface water Toolate sites from surface anvironment Standard technology	In place In place Beneining shallow groundester available for flow off Base

TABLE 5.3 (Continued)

Messure	Description	Major Pequired Equipment	Required Long-Term Operations	Short-Term Impacts	Long-Term Impacts	Advantages	Disadvantages
Trestment	Install air injection walls into affected soil material. Inject hot air into will and apply pressure to remove volatiles.	. Injection wells . Air blowers . Heat generators . Carbon adsorption unit for air treatment	M one	Distuption to localized Base areas	Removal of volatile organic constituents	Memoval of volatile organic constituents	Personal of volatile constituents only Affected groundster would remain. Permeability of affected soils too low for injection Potential air quality impairment. Hot a proven technology
In Situ Extraction with Bol- vents	Inject leaching fluid into affected metalis. Install wells downgradient from site to remove seepage from leaching process. Treat leachare with air stripping, carbon adsorption, coagulation/floculation depending on solvent used.	- Injection equipment - Leaching fluide - Evacuation wells - Treatment units - Injection wells	S on e	Disruption to localized Base areas	Leachate removal from potentially affected shallow groundwater	Removal of soil contaminants from soil column	Fermeability of soils too low for injection of any leaching fluid Affected groundwater would remain Leachetes could senter shallow groundwater Removal of leachetes in the groundwater would be inhibitive due to low permeability of sands Forcustion walls may not remove all impacted water Not a proven technology

TABLE 5.3 (Continued)

Me a sur e	Description	Me jor Required Equipment	Required Long-Term Operations	Short-Term Impacts	Long-Term Impacts	Advantages	Disadvantages
In Situ Microbial Decomposi- tion	Inject organic digenting microbes into affected materials.	Injection aquipment Microbes adapted to specific waste/aoil materiels Injection wells	None	Disruption to localised Base areas	Inorganic constituents remain in the soil column	Contactnants	Permeability of soils too low for injection of microbes Affected shallow groundwater would remain inorganic constituents would remain in soil column. Not a proven technology
Pi kation	Inject fixant into affected materials to ismobilize contaminants.	ogulpment Fixants selected for particular materials Injection Wells	Mon. ●	Disruption to localized Base areas	Immobilization of soil conteminants	leolation of contaminants from environment	Permeability of soils too low for injection of any fixant. Affected shallow groundwater would remain. Difficult to assess effectiveness effectiveness technology
In Situ Ges Injection (Air Stripping)	Install air injection wells into affected material. Pressurize air to "strip" voletile organics or use reverse system by applying vacuum process.	. Injection wells . Air blowers/ vacuum systems . Carbon adsorp- tion unit for air stripping treatment	Mone	Disruption to localized Base areas	Highly volatile organics would be removed	Removal of highly volatile organics	. Mon-volatile and low-volatility constituents would remain in soil . Affected ground-water would remain . Permeability of affected soils too low for injection . Potential air quality impairment . Mot a proven technology

TABLE 5.4

ALTERNATIVE CORRECTIVE MEASURES AND ASSOCIATED SITES CONTAINING APPECTED MATERIALS MCLELLAN AFB, CALIFORNIA

						Alternative Corrective Measures	ective Measures			
		:	Excavation/	Excavation/	Excavation/	Excavation/	Excevation/		BCRA	
Area	Site Containing Affected Material	Hee Bource Affected Groundwater	Off-Base Landfill	On-Bese Lendf111	Heat Treatment	Extraction With Solvents	Microbial Decomposition	Excavation/ Fixation	Site	Capping
	52	Partially covered by	south end of	by south end of runway overrun	5					
	37	-	in 1956 (see Table 2.1)	10 2.1)						
	9.	Site is Building 475								
	39	farm buil	t over site							
	2	¥••	×	×		×	,		×	
•										
	30	χ	×	×	×	×	×	×		×
	35	Material removed in 1	in 1950 (see Table 2.1)	10 2.1)						
	36	Open storage area								
		(See Table 2.1)								
U										
Subarea C-1	₩ C-1									
	1.1	Not Identified								
	18	Not Identified								
	19	Not Identified								
	20									
	21	Not Identified								
	22	Not Identified								
	38	Not Identified								
	32	Not Identified								
	7	Yea	×	×		×		×		×
	42	1 X 9	m i	M 1	×	34 1	×	× 1		M I
Subarea C-2			•	4		•		4		4
		Yes	×	×		×		×		×
	•	Yes	×	×		. ×		*	×	*
	•	Yes	×	×		×		. *		×
	2	Yes	×	×		×		×		×
	-	Yes	×	×		×		×		×
	12	Not Identified								
	13	Not Identified								
	*	Not Identified								
	15	Not Identified								
	9	Not Identified								

						Alternative Corrective Measures	ective Measures			
Mrna	Site Containing Affected Naterial	Mag Bource Affected Groundwater ^a	Excevetion/ Off-Base Landfill	Excevation/ Excevation/ Excevation/ Off-Base On-Base Heat Landfill Landfill Treatment	Excavation/ Heat Treatment	Excavation/ Extraction With Solvents	Excavation/ Microbial Decomposition	Excavation/ Fixation	BCRA Site Closure	Capping
۵										
	-	Not Identified								
	~	Yes	×	×		×		*		*
	•	Yes	×	×		: *		: >		٠,
	▼	Yes	×	×		: *		4 ×	,	< >
	'n	Yee	×	×		* **		. >	4	٠,
	v	Y••	×	×	×	: *	×	. *		< ×
	36	, de	×	*		•		,		. .
	27	Yes	: ×	: 14		• •		n 1		×
	33	Not Identified	ı	ı				•		×
Isole	Isolated Sites									
	23	Material removed in 1	In 1970 (see Table 2.1)	10 2.1)						
	24	Not Identified								
	53	Not Identified								
	31	Not Identified								
	*	Not Identified								
	45	Not Identified								
	97	7	In 1981 (see Table 2.1)	10 2.1)						

a Based on Table 4.23. X Technology has potential application based on site contents delinested on Table 2.1,

ON-BASE WATER SUPPLY

Problem Definition

Prevention of contamination of the Base water supply wells is of prime importance to the environmental health of Base personnel. Since the shallow aquifer contains the highest concentrations of chemical constituents within the aquifer systems underlying the Base, the objective for securing the Base water supply will be to prevent shallow aquifer water from entering deeper water-bearing sands.

Chemical constituents may enter the deeper water supply aquifers through the gravel pack of existing water supply wells or deeper monitoring wells. The following sections outline a methodology that should preserve the existing water supply wells while preventing introduction of shallow aquifer constituents into the deeper aquifer systems.

Affected Wells

Any well that has been constructed with continuous gravel pack from the shallow aquifer (occurring at depths less than 80 feet) to the deeper aquifers, and/or perforations within the shallow sands zone, constitutes a potential conduit for chemical constituent migration. Any monitoring well that has been completed with gravel packs at depths greater than 105 feet likewise constitutes a potential conduit. It should be noted that some production wells were constructed in the 1930's and 1940's when the most common drilling method used a cable-tool drill rig. Cable-tool wells do not contain gravel packs, and therefore would not allow constituent migration into deeper aquifers unless perforations were present within the shallow aquifer zone. Table 5.5 lists the known physical characteristics of all Base production and monitoring wells that could be considered as possible constituent conduits.

Well logs available for certain Base production wells indicate that they are all gravel packed except for BW17; this well does not have a gravel pack, and was therefore probably constructed by the cable-tool method. Four monitoring wells constructed in 1980 were gravel packed from the shallow aquifer to depths exceeding 200 feet.

TABLE 5.5

WELL CONSTRUCTION PARAMETERS FOR AFFECTED BASE PRODUCTION AND BASE MONITORING WELLS
MCCLELLAN AFB, CALIFORNIA

					Piret		
well Number	Year of Construction	Drilling Method	Depth of Caeing (feet)	Gravel Pack Interval (foet)	Perforation Interval (feet)	Casing Diameter (inches)	Casing
Production Wells							
•_	1937	Unknown	00\$	004-0	162-177	13	steel
3 .	1937	Unknown	298	0-298	100-112	12	steel
•	1943	Unknown	396	0-398	170	12	steel
6	1943	Unknown	625	0-625	None	10	steal
a 02	1945	Unknown	00₽	0-400	170-392	14/10	steel
4 _	1945	Unknown	00₽	0-400	154-346	14/10	steel
12*,h	1943	Unknown	390	0~390 (2)	164-390	=	steel
13p	1945	Unknown	391	0~391 (7)	178-300	14/12	steel
1.7	1943	Cable tool	353	none	216-224	7	steel
- 0 - 1 - 0 - 1 - 1 - 1 - 1 - 1 - 1 - 1	1954	Unknown	00₹	0-400	169-185	±	steel
20	1954	Unknown	909	0-600	178-190	-	steel
28	1968	Unknown	247	0-247	None	•	steel
59	1980	Air	499	0-499	Unknown	12	steel
Monitoring Wells							
-	1 980	Auger	249	75-249	75	•	PVC
7	1980	Auger	249	15-249	25	•	PVC
•	1980	Auger	205	70-205	70	•	PVC
•	1980	Auger	249	85-205	85	•	PVC

a Well closed down b No logs available

Available Alternative Corrective Measures

To ensure that the water quality of the water supply wells is not impaired by the introduction of shallow aquifer water into the system, the gravel pack conduits must be eliminated. Even if the wells were abandoned and removed from production, the gravel packs could still act as conduits in the future.

The gravel packs should be sealed by grouting to prevent downward migration of constituents from the shallow aquifer. In a typical well, this could be accomplished from inside the well casing or from outside the well. Since all the Base production wells are located within housing structures, there would not be enough space to accommodate the equipment needed to seal the gravel packs from inside the well casing. Therefore, sealing the gravel packs would have to be accomplished from outside the well housing.

Monitoring wells 1 and 2 are 249 feet deep and gravel packed from 75 feet downward; they were both abandoned shortly after installation. MW1 was grouted within the entire casing, but the gravel pack was not grouted. In MW2, the casing was grouted from 120 to 249 feet, with perforations starting at a 75-foot depth. MW3 and MW4 have not been grouted; they reach depths of 205 feet and 249 feet, respectively.

The gravel pack around the Base production wells can be sealed by using a slant rotary-wash drilling method. Slant holes could be drilled at compass points around the well down to the estimated depth of the shallow aquifer (a minimum of 75 feet). When the gravel pack is reached, it could be pressure grouted. The grout should be injected from a 75-foot depth to an estimated depth of 120 feet. In BW2 the perforations in the casing begin at a depth of 100 feet, or in the vicinity of the shallow aquifer. Therefore, if the gravel pack were to be pressure grouted in this interval, the grout would probably enter the well casing. This would result in total abandonment of BW2, unless the well housing were removed to allow space for drilling equipment to operate The remaining production wells to be sealed adjacent to the well. include Base wells 7 (abandoned, but the gravel pack not sealed), 8, 10, 11, 12, 13, 18, 20, 28, and 29, assuming that they are all gravel packed. Since there are no well logs available for Base production wells 10, 11, 12, and 13, it is unknown if they were gravel packed or completed with cable-tool methods. To ascertain the drilling method used, a video camera can be lowered into the well, and an experienced drilling contractor can determine the drilling method by examining the type of perforations in the well casing. This would determine the need for gravel-pack sealing of Base production wells 10, 11, 12, and 13.

Sealing of the deep monitoring wells 1, 2, 3, and 4 can be accomplished by pressure grouting directly in the well casings. The grout would flow through the perforations in the well casing to the desired elevation. These monitoring wells could be pressure grouted to depths of 100 feet to ensure discontinuity between the shallow and deeper acquifers.

Regular monitoring of the water quality in the production wells would determine the effectiveness of well-sealing over time.

OFF-BASE WATER SUPPLY WELLS

Problem Definition

The direction of shallow groundwater movement is to the south-southwest except where locally influenced by off-base pumping near the western Base boundary. Three wells downgradient from the Base have been closed as a result of contamination; those wells are within approximately 1,000 feet of the Base boundary. Other private and public wells are located farther downgradient, but have not shown excessive concentrations of chemical constituents. It therefore may be inferred that the average distance of shallow groundwater travel away from the Base boundary in the past 40 years has been about 1,000 feet, with local variations due to off-base pumping.

Migration of constituents into existing off-base wells could have occurred through well gravel packs or perforations within the shallow aquifer. However, the well construction of these wells is unknown.

Affected Wells

If the behavior of the shallow groundwater were to follow the same pattern as is p^{-} ently observed, it would move farther downgradient away from ' 10 \sim 50 boundaries. Within a 5,000-foot radius south and

west of the Base, 14 public wells are known to be located to the south and 13 to the west. The area west of the Base is without public water service. Most homes in the area rely on individual private wells for domestic water supply. Thirteen wells were tested by Sacramento County in 1979 through 1980. One well was found contaminated and was closed. The City of Sacramento provides public water service south of the Base. Future monitoring of the off-base wells could determine potential direction and rate of contaminant migration. Table 4.21 presented the range of constituent concentrations that have been identified in the shallow groundwater, and therefore could be available for migration off Base.

Alternative Corrective Measures

Protection of off-base water supplies from migration of constituents contained in the shallow groundwater aquifer could be accomplished by a variety of measures. The measures could be categorized as either (1) interception of shallow groundwater flow prior to its moving across the Base boundaries or (2) protection of each individual downgradient off-base well from shallow groundwater flowing uninhibited off Base. Table 5.6 summarizes available corrective measures for either protecting each off-base well or intercepting and treating the shallow groundwater around affected areas or at Base boundaries.

Corrective measures applied directly to affected off-base wells would entail sealing the gravel packs of these wells at the depth of the shallow aquifer, or abandoning the affected wells and properly reinstalling new wells. It should be noted that the shallow aquifer is a very poor producer of water, and sealing the gravel pack through the shallow aquifer would not affect the quantity of water available. In addition, the Air Force could advise agencies regulating well installations (e.g., County Public Health Department) that new wells should be constructed with perforations or gravel packs below a minimum depth of 120 feet. This alternative measure would protect the public health downgradient from the Base but would not result in removal of affected groundwater from the downgradient hydrologic regime.

TABLE 5.6

ALTERNATIVE CORRECTIVE MEASURES FOR OFF-BASE WELLS MCLELIAN AFB, CALIFORNIA

Alternative Measure	Description	Major Required Equipment/ Materials	Required Long-Term Operations	Short-Term Impacts	Long-Term Impacts	Advantages	Disadvantages
Seal gravel	Geal gravel packs in off-base wells to a depth of 100 feet. In wells with perforations in the upper sands sone, either use packers in casing, pressure grout through perfors- tions, or abandon well by pressure grouting entire	. Orill rigs . Fressure grouting equipment	Mone	Mon.	Protection of desper aquifers	Protection of downgradient private and public wells within areas enticipated to be impacted over the next 80 years Protection of public health Rause of closed wells	Mone
Regulate in- atallation of future off-base	Coordinate well installation guidelines with local regulatory agencies to avoid gravel packs and perforations to depths of 120 feet.	Mone	Mell installation inspection program	Mone	Protection of local water supply systems from shallow aquifer constituents	Protection of public health	Mone

Alternative Measure	Description	Major Mayuired Equipment/ Materials	Required Long-Term Operations	Short-Term Impacts	Long-Term Impacts	Advantages	Disedvantages
install upgradient slurry trench at affected Base boundaries	Divert shallow groundwater flow around the Base. This would prevent recharge to shallow aquifer on the Base leading to eventual drying out of shallow sands.	- Math-moving equipment for excavation of trench and emplecement Slurry materials	• Mone	None	Elimination of shallow ground-water under Base	Diversion of shallow ground-water currently flowing under affected base sites and off Base	Drying out of shallow aquifer, which acts as interceptor for constituents moving vertically, could permit constituents to migate vertically to water supply aquifers
Install down- gradient slurry walls at affected Base boundaries	Prevent shallow groundwater from leaving the Base. Groundwater behind shury wall would be pumped out, treated, and made available for other uses. Pumps would be spaced at very close intervals.	Earth-moving equipment for tranch excavation. Slurry materials. Pumps to evecuate groundwater behind slurry wall. Treatment facilities for evecuated groundwater helipton or distribution systems for treated water	Maintenance Traitment Traitment Traitment Traitment Tenance Distribution System main- tenance	. Prevents addi- tional shallow groundwater from leaving Base . Of f-base aban- doned wells would remain abandoned	No affacted groundwater would flow off Base	placontinuation of shallow ground-water flow off page	Extensive excavation High maintenance of evacuation pumps High potential for failure of pumps due to low yield of shellow sands

Alternative Measur:	Description	Mejor Mequired Equipment/ Materiale	Required Long-Term Operations	Short-Term Impacts	long-Term Impacte	Advantages	Disadvantages
Install slury valls sround affected sites	Isolate affected sites from shal- low groundwater flow regime by surrounding oach affected site by a slurry well.	. Earth-moving equipment for trench excavations . Blurry materials	None	Prevents further contribution of chemical constituents to stituents to shallow groundwater from affected sites	Elimination of constituent contribution from affected altes to shallow groundwater of off-base water quality in shallow equifer	Eliminate contact between affected areas and shallow groundaster	Extensive excavation activities Difficult to install down to groundwater Not recommended for containment of caustic wastes
Install upgradient evacuation wells at affected bese bounderies	Burround effected Base boundaries with pumping wells to prevent recharge to shallow sands underlying Base. Evacuated water would be dacharged for overland flow (less than 1 gps).	tion equipment . Evacuation pump . Overland-flow distribution system	Evacuation pump maintenance	Mon.	Elimination of mhallow ground-water under Bane	Elimination of shallow ground-water flowing under the Base	High maintenance and tharefore potential for failure. Shallow sands have low permeabilities, so pumping would be discontinuous and the wells would need to be apaced at extremely close intervals around hase boundaries would remain available for off-base flow for possibly i,000 years
Install evacuation wells down- gradient from affecteil areas	Intercept shallow groundater flows downgradient from each affected site with pumps spaced at extremely close intervals. Treat evacuated water and discharge	ation equipment Evacuation pumps Treatment facil- ities for evac- usted ground- water Overland-flow distribution system	Maintenance of evacuation pumps, treatment system, distribution system	Prevents any more shallow ground-water from mi-gration off Base	Elimination of constituents entering off-base shallow groundwater	Eliminates off-base flow of shallow ground- water	of pumping system of pumping system wells would be required at extremely close intervals Cost to treat evacuated groundwater

Alternative Measura	Description	Major Maguired Ruipment/ Materials	Required Long-Term Operations	Short-Term Impacts	Long-Term Impacts	Advantages	Disadvantages
Inject water to create groundwater sound around affected aries	Create a ground- water mound acting as a barrier for off-base shallow groundwater movement. Upgradient evecuation wells would pump ponded water out of aystem for treat- ment and disposal.	. Injection wells upgradient from injection wells injection wells water treatment system is the factor distribution system	Maintenance of evecuation and injection pumps and water distribution system	Prevents Constituents Currently in shellow ground- water from moving off Base	No off-base flow of shallow groundwater	Prevente further off-base migration of constituents in shallow ground-water	. High maintenance . Injection vella needed at close intervals . Evacuation vells needed at extremely close intervals
Inject water to create groundwater ground acound affected areas	Place injection wells around each affected area. Interest in the stall evecuation wells inside mound area for removal and treatment of contaminated water and distribution of treated water.	at close inverse inver	Maintenance of evacuation and infection pumps, water treatment and water distribution system	Prevents further contribution of contribution of schellow ground-water from affected sites	Constituents currently in shallow groundwater would be moving off Base	Prevents further contribution of constituents from affected sites to shallow groundwater	Ghallow groundwater outside mounds still available for off-base migration Installation of injection and evacuation vells at axtremely close intervals High pump maintenance program
install Franch drain along affected base boundaries	Excavate trench beyond shallow aquifor and emplace rock fill. Cover drain and install wall points to evacuate water. Treat water and discharge for other uses.	Excavation equipment Nock material for drain pumps Trattment facilities Mater distribution system	. Frankmaintenance . Treatment system maintenance	Interception of shallow ground- water flowing off-base	Elimination of potential constituent sources for off-base wells in shallow groundwater	Frevents off-base flow of shallow groundwater into private and public wells	Extensive excavation of trench to a depth of 100 feet. Pump maintenance. Cost of treating evacuated water

TABLE 5.6 (Continued)

Alternative Mesure	Description	Najor Bequired Equipment/ Naterials	Mequired Long-Term Operations	Short-Term Impacts	Long-Term Impacts	Advantages	Disadvantages
Install sumps and devatoring pipes along affected downgradient Base boundaries	Excavate localized . Excavation shafts to shallow equipment groundwater and . Devatering drive dowtering . Pumps pipes laterally . Treatment along the base of facilities the shallow aquifer. Install pumps within shafts to remove draining shallow groundwater. Treat and distribute water.	. Excavation equipment . Devatering pipes . Pumps . Treatment facilities	Maintenance of de- Interception of water treatment water flowing system off base	Interception of shallow ground-water flowing off hase	Elimination of potential constituent sources for off-base wells in shallow groundwater	Prevents off-base flow of shallow groundwater into private and public wells	Extensive excavation, but only in localized ereas

Removal of affected shallow groundwater could be accomplished along the Base boundaries by installation of downgradient slurry trenches or groundwater evacuation pumps, by creation of groundwater mounds, or by construction of French drains or sumps at the depth of the shallow sands. Any of the above structural alternatives could be applied to specific disposal sites or areas as listed in Table 5.4. It should be noted that if structural methods were employed on a site-specific basis, the existing affected groundwater would remain available for off-base migration. In addition, if corrective measures were applied along the Base boundaries, affected groundwater already off Base would continue to move downgradient, potentially affecting other wells in the future. Since the groundwater movement is extremely slow except when accelerated by local pumping, these effects will probably not occur for many years.

At McClellan AFB, affected groundwater is contained in an aquifer an average of six feet thick which possibly extends the length of the Base. The permeability of this aquifer probably averages close to 2.5 gpd/ft2. The aquifer is flowing at a gradient approximating 0.01 percent. The flow of the aquifer is therefore approximately one gallon per foot of cross-section per day. Based on pump test results, a well in this aguifer would be capable of pumping no more than 150 gallons per day. To pump out the aquifer would therefore theoretically require one well for every 150 feet of cross-section. However, the cone of depression for each well would extend only a few feet from the well point because of the low permeability of the shallow sands. order for the cones of depression to interfere with each other, the well points probably would have to be placed closer than one foot on center. Such a system is probably infeasible under these conditions. This means that alternatives which entail pumping water from the first sands zone or injecting material into the ground will not work at McClellan AFB. Further discussion on this limitation is contained in Appendix T.

SECTION 6

RECOMMENDATIONS

CHAPTER 6

RECOMMENDATIONS

The following recommendations for preventive or corrective measures will accomplish the protection of public health on and off the Base, as well as mitigation of environmental impacts that have occurred or may occur off Base as a result of past disposal and storage practices at McClellan AFB. The recommendations are divided into three categories addressing the impacts of affected materials, on-base water supply, and off-base water supply. These recommendations are summarized on Table 6.1. Included with the recommendations is a recommended priority for implementation.

AFFECTED MATERIALS

Chapter 5 discussed the estimated volume of affected disposed material as well as the total volume of affected material reaching to the shallow groundwater. The extensive volumes which would require disposal or treatment following excavation would cause this approach to be prohibitively costly. Table 4.23 delineated the sites that may have affected groundwater quality. Excavating solely the disposed material in these sites would amount to over an estimated one million tons of material to be hauled and disposed. Removal of the affected materials would not mitigate the existing shallow groundwater quality problems.

It is therefore recommended that Sites 4, 8, and 40 be closed to meet RCRA requirements. This will entail development of a closure and post-closure plan that must be approved by the California Department of Health Services. Disposal site 4, the currently open sludge pit, should be abandoned by placing 4 feet of soil/cement mixture into the pit to absorb available moisture. The site should then be graded and capped with impermeable material to prevent infiltration of surface moisture.

TABLE 6.1

RECOMMENDED ACTIONS AND MONITORING MCCLELLAN AFB, CALIFORNIA

Problem	Recommended Action and Monitoring	Rationale	Implementation Priority
Affected Materials	* Ensure that Sites 0 and 40 are closed to meet RCRA requirements	* Prevent precipitation moisture from contacting affected materials/Most MCRA require- ments	2
	• Close Site 4 to meet ACRA requirements to include placing 4 feet of soil/cement mixture within the pit, and subsequently cap the site to prevent surface infiltra- tion	* Absorb molsture on pit surface/ Prevent precipitation molsture from contacting affected materials	-
	* Inspect sites in Area A (25), Area B (30), Subarea C-1 (41, 42, 43) Subarea C-2 (7, 8, 9, 10, 11), and Area D (2, 3, 4, 5, 6, 26, 27) to evaluate status of surface conditions. Cover sites with impermeable cap designed to divert surface water from the site	* Prevent pracipitation moisture from contacting affected mate- rials	• Area D: 2 • Subarea C-1: 3 • Area B: 3 • Subarea C-2: 4 • Area A: 4
On-Base Water Supply	• Seal gravel pack on Base production wells 1, 8, 13, 18, 20, and 29 • Abandon BW2 and seal gravel pack • Seal gravel packs in MW1, 2, 3, and 4	· Prevent affected shallow groundwater from entering Base water supply eystem	•
	 Rehabilitate industrial wasta line in front of Building 251 	* Minimize amount of exfiltra- tion from pipeline to the first sands sone	2
	• Nemove manhole 33A and associated lines	 Prevent accumulation of sludge and eliminate potential contami- nation 	~
	 Conduct investigation on remaining Base industrial waste line 	 Identify potential areas of exfiltration into the first sands zone 	•
	* Sample monitoring wells annually $_{\boldsymbol{b}}$ and Base production wells southly	• Monitor wells to determine effectiveness of corrective measure	-
Off-base Water Supply	* Inform local governmental agencies of the need to set up regulations that require a 120-foot samitary seal for new wells installed in the area	· Prevent new wells from provid- ing migration route between water-bearing zones	-

TABLE 6.1 (Continued)

Problem	Recommended Action and Monitoring	Rationale	Implementation Priority
	 Inform local agencies of the need to seal gravel packs to a depth of 120 feet on private and public wells along affected mase boundaries 	* Prevent shallow groundwater antering water mupply wells	-
	• Inform local agencies of the need to monitor public and private wells semiannually within a 5,000-foot bradius of affected Base boundaries	* Provide early detection of downgradiant migration of affected shallow groundwater	-
	 Investigate feasibility of constructing interception system along affected Base boundaries 	* Develop system to prevent off-base migration of affected groundwater	•

a Priorities are ranked as 1 being highest and 4 the lowest. b Well samples should be analyzed for: volatile compound (TCE); acid compound (pentachlorophenol); base/neutral compound (1,2-dichlorobenzene).

6-3

No further action is recommended for Site 46, from which soils containing PCB's have been removed by the Air Force and transported to an approved PCB site.

To prevent precipitation moisture from contacting affected materials it is recommended that sites found to impact groundwater quality be capped with an impermeable barrier. The barrier may be constructed of asphalt, concrete, clay, or other suitable material depending on the individual site location in relation to Base activities. Each site should be inspected to determine if a cap is necessary. This inspection may include physical and chemical analysis of surface materials. Affected sites and corresponding areas are delineated on Table 6.1. Because of the level of constituents in the groundwater beneath Area D it is recommended that sites in this area be given top priority.

ON-BASE WATER SUPPLY

To protect the on-base water supply it is recommended that Base production wells known to have gravel-packed casings be sealed by slant drilling at depths from 75 feet to 120 feet. This would include Base wells 1, 7, 8, 18, 20, and 29. For Base wells 10, 11, 12, and 13, for which no well logs exist, video cameras should be lowered into the wells to ascertain whether they were constructed by cable-tool methods. If they were constructed by cable tool, there would be no gravel packs, and the wells would require no further corrective measures. If the wells did have gravel packs, sealing would be required by slant drilling. Base well 2, with perforations starting at 100 feet, is located in an inaccessible well house. The well house should be removed and the well abandoned by pressure grouting the gravel pack through existing perforations.

Base monitoring wells 1, 2, 3, and 4 should be abandoned by sealing the gravel pack. This can be accomplished by pressure grouting directly into the well casings; the grout would flow through the perforations and move into the gravel packs.

Although the industrial waste line near Building 251 was found to have potential exfiltration problems, the constituents in water from nearby closed production wells were not the same as those found in the

soil beneath the line. However, the industrial waste line could be a constant source of water for recharge into the first sands zone. In addition, trace metals were found in soils beneath the industrial waste line which could leach into the water-bearing zone. To eliminate this possibility other portions of the industrial waste line should be examined across the Base. The line in front of Building 251 should be surveyed and inspected for structural integrity, then repaired or replaced depending on the results of the survey. Abandoned manhole 33A and the inlet and outlet lines should be removed.

After sealing Base supply wells and Base monitoring wells, monitoring should be implemented on a regular basis and should continue indefinitely until such time as deemed no longer necessary. As noted on Table 6.2, Base supply wells should be monitored monthly and all monitoring wells should be monitored annually. Constituents to be analyzed should include a tracer from the following groups: volatile compounds (TCE), acid compounds (pentachlorophenol), and base/neutral compounds (1,2-dichlorobenzene).

TABLE 6.2

MONITORING PROGRAM FOR ON-BASE AND OFF-BASE WELLS

MCCLELLAN AFB, CALIFORNIA

Wells to be Monitored	Monitoring Frequency
Base Production Wells	Monthly
Monitoring Wells	
Base monitoring wells	Annually
Stages I and II wells	Annually
Off-Base Wells	
City Wells	Semiannually
(150, 132, 131, 137, 127, 136, 126, 138,	•
135,155,50,48,61, and 52)	
Private Wells	Semiannually
13 wells west of Base within	
5,000-foot radius	

a All wells should be analyzed for:

^{1.} Volatile compound (TCE)

^{2.} Acid compound (pentachlorophenol)

^{3.} Base/neutral compound (1,2-dichlorobenzene)

OFF-BASE WATER SUPPLY

It is recommended that efforts to protect off-base water supply be initiated immediately by informing local agencies of the need to seal affected well gravel packs to a depth of 120 feet. In addition, contacts should be initiated with the local regulatory agencies to ensure that new wells being installed downgradient from the Base boundaries are grouted to a minimum depth of 120 feet.

Because of the geological formation of the first water-bearing sands beneath McClellan AFB, pumping removal of affected water or injection of grout curtains or slurry walls is not practical. The installation of a French drain by conventional trenching and shoring techniques is also not feasible because of the depth to groundwater. To prevent future migration of affected shallow groundwater off Base it is suggested that investigations be initiated to determine the feasibility of construction of an interception drain system along affected Base boundaries.

If such a system is determined to be feasible, individual drain units could be installed at about 1,000-foot intervals along affected Base boundaries. Evacuated water then could be pumped to the existing industrial wastewater system or to a small package treatment unit. Based on flow calculations the treatment system would have to be large enough to handle between 15 and 20 gallons/minute from the entire downgradient Base boundary. Treatment would probably consist of air stripping, carbon adsorption, and possibly coagulation/flocculation. The exact nature of the treatment system would be determined by performing pilot tests on groundwater samples.

It is recommended that the development of an interception pipe be initiated as a Phase III action under IRP. Since this is an unproven technology it is recommended that a scaled-down field demonstration be conducted to evaluate feasibility. If feasibility is proven then installation of such a system downgradient from Area D is recommended. That installation would include intensive monitoring to determine full-scale system effectiveness. If proved effective the system would then be installed downgradient from other areas in the following priority: Subarea C-1, Area B, Subarea C-2, and Area A.

APPENDIX A SCOPE OF WORK

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INSTALLATION RESTORATION PROGRAM PHASE II FIELD EVALUATION McCLELLAN AFB, CALIFORNIA

I. DESCRIPTION OF PROPOSED TASK

The purpose of this task is to determine the magnitude and extent of environmental contamination which has resulted from previous waste disposal practices at McClellan AFB, California; to make recommendations for actions necessary to mitigate adverse environmental effects of existing contamination problems; to suggest potential ways of restoring the environment to as near a normal level as is practical; and, to suggest a future environmental monitoring program to document environmental conditions at McClellan AFB.

The presurvey task (Order 18) report incorporated background and description of the sites for this task. To accomplish this survey effort, the following steps will be taken.

- A. Review all available background data to develop a comprehensive working knowledge of past and present base operations as they relate to use and disposal of potentially hazardous materials. Included in this review will be the Phase I IRP survey report for McClellan AFB prepared by CH₂M Hill, Inc. of Gainesville FL, and the Final Report for Investigating Groundwater Contamination as of 30 April 1981, for McClellan AFB by Bruner and Zipfel of the Air Force.
- B. Visit McClellan AFB and obtain samples, from the twelve (12) existing monitoring wells. A total of twelve (12) samples should be collected from these wells and analyzed for TCE content and organic priority pollutants using GC/Ms.
- C. Samples will be collected from ten (10) production wells located at McClellan AFB. Four (4) wells are known to be contaminated. Samples will be collected from each of these four (4) wells; six (6) other production wells will also be selected for sampling. A total of ten (10) samples will be analyzed for organic priority pollutants utilizing GC/MS and for TCE content.
- D. All of the foregoing data will be reduced and a drilling program will be developed to produce further data required to characterize the problem.
- E. Upon Air Force review of the preliminary analysis and recommended well drilling program, the well drilling phase will be implemented. A total of thirty (30) monitoring wells will be installed in two (2) stages. In this effort, fifteen (15) wells will be installed in Stage I. Samples will be collected from each of these wells and analyzed for organic and heavy metal priority pollutants utilizing GC/MS and AA. Based upon these results and other information gained in Stage I, Stage II will be implemented. In this stage, fifteen (15) additional monitoring wells will be located and installed. Samples will be collected from each of these fifteen (15) wells and analyzed for organic and heavy metal priority pollutants utilizing GC/MS and AA.

- F. All of the information developed in Stage I will be integrated with that or Stage II and an interim draft report will be developed. Recommendations will be made and further drilling needs will be identified.
- G. The total magnitude and extent of contamination found in Stages I and II must be identified. To accomplish this task, a total of twenty-three (23) additional monitoring wells will be installed. Samples will be collected from each of these twenty-three (23) monitoring wells. An additional thirty (30) samples will be collected from monitoring wells previously installed at McClellan AFB. The following numbers and types of analyses shall be performed on appropriate samples: 23 heavy metals; 53 GC/MS organic scans; and 53 cyanide tests.
- H. Production Well Number 7 at McClellan AFB was closed because of cresylic acid contamination many years ago. The exact location of this well is not known. The contractor will review CE records of buried water distribution facilities in order to localize the search area. The contractor will locate Well Number 7, excavating as required. A steel casing will be installed to bring the wellhead to ground surface. An attempt will be made to clean out and sample the well. If the well cannot be sampled, one of the monitoring wells from Task G above will be installed in this area. Four ground water samples will be obtained from wells in this area and analyzed for cresylic acid.
 - I. Contamination of the ground water by aliphatic hydrocarbons is suspected in the area around Bldg 704. Four ground water samples will be obtained from monitoring wells in this area and analyzed for aliphatics.
 - J. A pump test will be conducted on Well Number 28 to determine general aquifer characteristics. Two (2) piezometers will be installed at predetermined locations. Water-level measurements will be taken duming pumping to determine aquifer characteristics.
 - K. A total of four (4) water samples shall be obtained from wells 17 and 18 near the old PCB site. These samples shall be analyzed for PCBs.
 - L. The integrity of the industrial waste collection system in the vicinity of Building 251 will be evaluated. The line will be temporarily plugged and flooded. The static water level will be monitored to determine if exfiltration from the industrial waste line is occurring.
 - M. Install three (3) ten-foot deep auger holes at selected locations along the industrial waste collection line in the vicinity of Building 251. Six (6) samples will be examined to determine if industrial waste contamination is occurring by performing GC/MS scans and heavy metal analyses.
 - N. Monitor ambient air quality for total hydrocarbon at each site described above during drilling operations.

- O. All wells installed by the contractor shall be in accordance with USATHAMA well installation guidelines. A copy of these guidelines has been provided to the contractor. Additionally, the bottom ten feet of well casing will be made of 316 stainless steel.
- P. Data collected in this task must be reviewed and assessed to include the following major items:
 - . 1. preparation of stratigraphic cross-sections,
- 2. preparation of graphical displays of principal data parameters,
- 3. preparation of piezometric surface maps for the shallow aquifer,
 - 4. preparation of a flow net map for the shallow aquifer.
- Q. Preliminary concept engineering analysis for remedial actions will be accomplished and conceptual remedial action plans prepared for each contaminated area discovered during this investigation.
- R. Prepare a final report which will document all survey activities conducted at McClellan AFB. This report will include applicable raw data, all maps and computations and all remedial action plans prepared pursuant to this project. The magnitude and extent of environmental contamination will be delineated. Recommendations for actions necessary to mitigate adverse environmental effects of existing contamination problems must be included. Potential ways of restoring the environment to as near a normal level as is practical will also be included. Future environmental monitoring programs necessary to document environmental conditions at McClellan AFB must also be included.
- S. McClellan AFB personnel will survey all monitoring wells described above. The wells will be surveyed to tolerances of \pm 3-feet horizontally and \pm 0.1 foot vertically.
- T. Meet with representatives of EQ AFLC/DE/SG, McClellan AFB/SG/DE, AFMSC, and the USAF OEHL four times during this project to review progress of investigations, and resolve problems which may be encountered. Two meetings will be held in Sacramento CA and two will be held at the Engineering Science Office in Arcadia CA.

II. SITE LOCATION AND DATES

McClellan AFB, California Bldg 334, Bioenvironmental Engineering

28 Sep 1981

III. BASE SUPPORT. McClellan AFB will provide adequate office and field laboratory space.

- IV. GOVERNMENT-FURNISHED PROPERTY: None.
- V. GOVERNMENT TECHNICAL POINTS OF CONTACT:
 - 1. Dr Dee Ann Sanders USAF OFHL/ECV Brooks AFB TX 78235 (512) 536-3305
 - 3. Mr Paul Bruner 2852 Civil Engineers/DEEX McClellan AFB CA 95652 (916) 643-3336
- 2. Lt Col Milo Myers
 USAF Clinic McClellan/SGB
 McClellan AFB CA 95652
 (916) 643-3672

APPENDIX B

KEY PROJECT PERSONNEL

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APPENDIX B

KEY PROJECT PERSONNEL

- D. R. Anderson
- F. R. Bowerman
- R. E. Brogden
- S. L. Deering
- J. T. DeZellar
- L. E. Doane
- J. Ehmann, Ph.D.
- F. C. Realy
- T. H. Luiten
- G. S. Magnuson
- J. L. Mang
- T. K. Martella
- Y. Nordhav
- J. L. Rubin

DCNALD R. ANDERSCN

Sanitary Engineer

PII Redacted

Education

B.S. in Civil Engineering, 1958, University of Miami, Florida M.S. in Civil Engineering, 1960, Purdue University, Indiana Radiation Physics, 1962, University of Cklahoma Mathematical Modeling of Biological Systems, 1972, Utah State University

Professional Affiliations

Registered Civil Engineer (Arizona No. 8654)
Registered Professional Engineer (California)
American Academy of Environmental Engineers (Diplomate)
American Society for Engineering Education
American Society of Civil Engineers (Chairman, Environmental
Engineering Group, Los Angeles Section, 1978)
Association of Environmental Engineering Professors
Citizens Advisory Committee - 208 Planning, Southern California
Association of Governments
Environmental Management Institute, University of California
Los Angeles Regional Forum on Solid Waste Management (Vice Chairman, 1981-1982)
United States Environmental Protection Agency Extramural Reviewer -

Solid Waste Management Projects
Water Pollution Control Federation (Secretary/Treasurer and WPCF
Bulletin Editor, California, 1963-1966)

Experience Record

1951-1953	United States Air Force Security Service. Russian Linguist.
1953-1958	General Building Contractor, Miami, Florida. Engaged in construction of residential, commercial, and industrial facilities.
1958-1960	Purdue University. <u>Instructor in Civil Engineering</u> . Responsible for teaching graphics and surveying.
1960-1965	Loyola Marymount University. Assistant Professor of Civil Engineering. Academic responsibilities included teaching sanitary engineering and soil mechanics.

1081 WQ#

Donald R. Anderson (Continued)

1965-1968 Engineering-Science. Manager, Research and Development Cffice. Projects included water quality master plans for Lake Tahoe and Napa Valley, California, and the San Francisco Bay-Delta.

1968-1969 Chio Northern University. Associate Professor of Civil Engineering. Responsible for teaching environmental engineering and hydraulics.

1970-Date Loyola Marymount University. Professor of Civil Engineering and Environmental Science. Serves as Program Director for graduate studies in environmental engineering.

1972-1973 Environmental Dynamics, Inc. <u>Project Technical</u>
<u>Director</u>. Projects included mathematical modeling of water quality in the Tahoe-Truckee-Carson Rivers system of California-Nevada and the Jordan River-Utah Lake system near Salt Lake City, Utah.

Toups Corporation, Division of Planning Research
Corporation. Project Technical Director. Responsible for operation of the Yuma Desalting Test
Facility for the U.S. Bureau of Reclamation; nonpoint runoff studies for Tucson, Arizona, and Crange
County, California; studies of the impact of abandoned mines on water quality in the United States for EPA; and studies of the impact of the Cregon Bottle
Bill on collection and disposal of solid wastes.

Engineering-Science. Project Technical Advisor. Responsible for technical direction of projects involving preliminary water quality studies and master planning, water resources development, solid waste management/resource recovery, and wastewater collection, treatment and disposal. Project activities include development of a master plan for wastewater management for the Greater Seoul, Korea, area. Served as Project Manager for conceptual design of an industrial waste management program for zero discharge for IBM at Tucson, Arizona.

Publications

1978-Date

"Gas Generation and Movement in Landfills," <u>Proceedings: National</u> Industrial Solid Waste Management Conference, Houston, Texas, March 1970 (Coauthor J. P. Callinan).

"Steady-State Water Quality Modeling in Streams," <u>Journal Environmental Engineering Division</u>, American Society of Civil Engineers, April 1975 (Coauthors J. Dracup and R. Willis).

Donald R. Anderson (Continued)

"Water Quality Modeling in Deep Reservoirs," <u>Journal Water Pollution Control Federation</u>, January 1976 (Coauthors J. Dracup and T. Fogarty).

"Transient Water Quality Modeling in Streams," <u>Water Resources</u>
<u>Bulletin</u>, American Water Resources Association, February 1976
(Coauthors J. Dracup and R. Willis).

"An Integrated Pretreatment System for Reverse Camosis," <u>Proceedings: International Desalination and Environmental Association</u>, Tokyo, Japan, December 1977.

"Application of Aerobic Composting in the Disposal of Liquid Palm Cil Wastes," <u>Proceedings: Asia Aquatech</u>, Singapore, Malaysia, March 1980 (Coauthors R. White and C. Ponniah).

"Surface Impoundment of Hazardous Wastes," Proceedings: Conference on Hazardous Materials Control of the Hazardous Materials Control Institute, Baltimore, Maryland, August 1981 (Coauthors F. Bowerman and J. Mang).

Patents

Magnesium Substitution Process for Removal of Calcium in Brines: U.S. Patent No. 4,036,749

Biological Cenitrification of Nitrate-containing Waters Using Cellulose as the Crganic Energy Source: U.S. Patent No. 4,039,048

FRANK R. BOWERMAN

Civil and Sanitary Engineer

PII Redacted

Education

B.S. in Engineering, 1947, California Institute of Technology M.S. in Civil Engineering, 1948, California Institute of Technology

Professional Affiliations

Registered Professional Engineer (California No. 8112)

American Academy of Environmental Engineers (Diplomate; President, 1973)

American Public Works Association (National Director-at-Large, 1974-1977; President, Institute for Solid Wastes, 1966)

American Society of Civil Engineers (Fellow; Vice President, Los Angeles Section, 1975)

California Water Pollution Control Association

Water Pollution Control Federation (National Director-at-Large, 1965-1968)

Honorary Affiliations

Charles Walter Nichols Award (American Public Works Association, 1965)
Government Refuse Collection and Disposal Association
Rudolph Hering Medal (American Society of Civil Engineers, 1962)
Chi Epsilon
Sigma Xi
Tau Beta Pi

Special Appointments

Smithsonian Institution (Consultant)

California Governor's Council on Earthquakes
California State Solid Wasta Management Board (1973-1975)
Pollution Committee, National Research Council/National Academy of
Sciences Summer Research Center at Woods Hole, Massachusetts
(1965)
President's Office of Science and Technology (Consultant)
Refuse Disposal Practices Committee, American Society of Civil
Engineers
Science Advisory Board, U.S. Environmental Protection Agency (Environmental Consultant)
Sewerage and Sewage Treatment Committee, American Society of Civil
Engineers (Chairman, 1952-1955)

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Solid Waste Advisory Committee, California State Department of Public Health

Solid Waste Management Committee, National Academy of Engineering United Nations Development Program (Consultant) United States Information Agency (Consultant)

U.S. Public Health Service (Consultant)

Waste Disposal Committee, Air Pollution Control Association (Chairman, 1955-1960)

Experience Record

1948-1966

Los Angeles County Sanitation Districts. Sanitary Engineer (1948-1958) and Assistant Chief Engineer (1958-1966). Developed and implemented a regional transfer station and sanitary landfill and hazardous waste management program to serve four million persons. Coauthored bulletin on municipal incineration as sanitary engineering consultant to the University of California.

Supervised a comprehensive investigation and report on the collection and disposal of refuse in the county sanitation districts as well as a report on planned refuse disposal. Represented the districts for preparation of a joint report with the Los Angeles County Flood Control District concerning the potential reclamation of sewage wasting to the ocean in Los Angeles County. Also participated in the study of sewerage, air and water pollution control, and solid waste collection and disposal throughout the United States.

1966-1968

Aerojet-General Corporation. Assistant to the Vice President - Development. Served as Program Manager for a solid waste management system study at Fresno, a typical urban/agricultural complex, for the California State Public Health Department under a matching fund grant from the U.S. Public Health Service, Department of Health, Education and Welfare. Directed a system study of solid waste management for the Kansas City Metropolitan Regional Planning Commission, funded under a matching grant from the U.S. Public Health Service, Bureau of Solid Waste Management, Department of Health, Education and welfare.

1969-1970

Engineering-Science. <u>Vice President</u>. Responsible for projects involving the design, construction, and operation of solid waste management systems for cities and industries.

1970-1975

University of Southern California. Chairman, Department of Civil Engineering (1970-1973).

Professor and Director of Environmental Engineering Programs (1970-1975). In responsible charge of the implementation of graduate degree programs in environmental engineering, as well as research and development projects and community-related educational activities.

1975-1978

CDM, Inc., Environmental Engineers. President. Directed operations of California-based subsidiary of Camp Dresser & McKee, Inc. Projects involved water supply, wastewater collection and treatment, drainage and flood control, solid waste management, and related areas of environmental engineering.

1978-Date

Engineering-Science. Senior Vice President. Responsible for management and conduct of environmental engineering projects involving such specialties as sewerage, marine waste disposal, solid and hazardous waste management, and water supply. Activities include facility planning, design, construction, and system operation assistance.

Serves as Director of hazardous waste management programs companywide. Conducts national and regional hazardous waste management seminars and supervises design of remedial hazardous waste control measures for industrial facilities. Served as project manager on development of a comprehensive solid waste management system for Orange County, California, and a study of the feasibility of co-disposal of municipal sludge and refuse for the Orange County Sanitation Districts. Served as technical director of hazardous waste investigations/groundwater monitoring studies and at two California Air Force bases as part of the U.S. Air Force's Installation Restoration Program - Phase II. Other recent projects include: investigation of soil and groundwater contamination at a semiconductor firm which included representation at government agency meetings for institution of an ameliorative program; investigation of trace metal distribution in soil to determine the extent of contamination which resulted from past handling practices at Drew Manufacturing Company in Berkeley, California; and development of soil and groundwater contamination cleanup programs at a semiconductor firm which involved sensitive negotiations with state and local agencies on acceptable ameliorative measures.

Publications

"Factors Influencing and Limiting the Location of Sewer Ocean Outfalls," <u>Proceedings of Institute of Coastal Engineering</u>, University of California, October 1950.

"Refuse Disposal Program for 27 Cities and County Area," Western City, December 1950.

"Past and Present Municipal Incinerators in the United States," American City, March 1952.

"Can Waste Heat from Refuse Incinerators be Employed Economically?," Civil Engineering, May 1952.

"Problems in Municipal Refuse," <u>Virginia Municipal Review</u>, May 1953.

"Integrating Reclamation and Disposal of Wastewater," <u>Journal</u> <u>American Water Works Association</u>, Vol. 45, No. 5, May 1953.

"Engineering Waste Disposal to Prevent Air Pollution," <u>Proceedings</u> of Conference on Incineration, Rubbish Disposal, and Air Pollution, Report No. 3, January 1955.

"The Membrane Filter: Advantages and Disadvantages," <u>Water and Sewage Works</u>, No. 103, January 1956.

"Refuse Collection and Disposal in the West," Western City, Part I, May 1958 and Part II, June 1958.

"Economic Aspects of Engineering Control - Land Disposal and Incineration," <u>Proceedings of National Conference on Air Pollution</u>, Washington, D.C., 18-20 November 1958.

"Diffusers for Disposal of Sewage in Sea Water," <u>Transactions of American Society of Civil Engineers</u>, Vol. 126, Part III, 1961 (Rudolf Hering Medal, 1961, American Society of Civil Engineers).

"Municipal Refuse Transfer Stations," American Public Works Association Yearbook, 1962.

"Los Angeles County Activities in Refuse Disposal," Proceedings of National Conference on Solid Waste Management, 4-5 April 1966.

"Changing Concepts in Pollution Control Hardware," American Engineer, January 1968.

"Comprehensive Planning: The Systems Design Approach, Part II of the Fresno Story," <u>Proceedings of Institute for Solid Wastes</u>, American Public Works Association, 1968.

"Land Pollution Abatement," <u>Investment Dealers Digest</u>, Section II, 27 May 1969.

"Solid Waste Disposal," Chemical Engineering Deskbook, 27 April 1970.

"A Decision Theory Approach to Solid Waste Management System Selection," American Public Works Association Yearbook, 1971.

"Environmental Impact of Storm Drainage on a Semi-Enclosed Coastal Water," Proceedings of Eighth Marine Technology Society Conference, 1972, pp. 763-770, (Coauthors K. Y. Chen and M. Petridis).

"Mechanisms of Leachate Formation in Sanitary Landfills," Recycling and Disposal of Solid Wastes (Ann Arbor Science Publishers, 1974), pp. 349-367 (Coauthor K. Y. Chen).

"Pyrolysis as a Means of Sewage Sludge Disposal," <u>Journal Environmental Engineering Division</u>, American Society of Civil Engineers, 1978 (Coauthors N. E. Folks, R. A. Lockwood, B. Eichenberger, and K. Y. Chen).

Papers and Presentations

"Microbial Decomposition of Oil and Clay Wastes in the Soil," presented at 45th Annual Conference, Water Pollution Control Federation, Cleveland, Chio, September 1973 (Coauthors B. Loran., Y. Tsai, and K. Y. Chen).

"Surface Impoundment of Hazardous Waste," presented at Hazardous Waste Disposal Seminar, Hazardous Materials Control Research Institute, Baltimore, Maryland, August 1981.

"Hazardous Wastes in Orange County, California," presented to Environmental and Engineering Council, Orange County Chamber of Commerce, Santa Ana, California, September 1982.

ROBERT E. BROGDEN

Hydrogeologist

PII Redacted

Education

B.S. in Geology, 1968, University of Nebraska
 M.S. in Civil Engineering, 1972, University of Nebraska
 Fortran IV Computer Programming, Groundwater - Surface Water Relationships, Modeling of Groundwater Flow, and Surface Geophysics, 1975-1976, U.S. Geological Survey

Professional Affiliations

National Water Well Association

Experience Record

1965-1968

U.S. Geological Survey, Water Resources Division.

Aide (part-time). Duties included geologic logging
of samples collected during test hole drilling programs, stream gaging to determine groundwater gains
and losses, inventorying irrigation and industrial
wells in select parts of the state, collection of
water samples for regional groundwater studies, and
drafting of maps, figures, and graphs for report
publication.

1965-1969

University of Nebraska, Conservation and Survey Division. Aide (part-time) (1965-1968). Duties included geologic logging of samples collected during test hole drilling programs, stream gaging to determine groundwater gains and losses, inventorying irrigation and industrial wells in select parts of the state, collection of water samples for regional groundwater studies, and drafting of maps, figures, and graphs for report publication.

Hydrogeologist (1968-1969). Responsible for collection and interpretation of hydrologic and geologic data and preparation of reports describing the occurrence of surface water and groundwater supplies throughout the state in connection with the county groundwater program. Participated in joint study with U.S. Geological Survey to identify groundwater and surface water resources of Pierce

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Robert E. Brogden (Continued)

County, Nebraska, and the Elkhorn River basin. Authored report describing the availability and chemical characteristics of groundwater and surface water in Pierce County. Participated in program to identify aquifer subcrops using surface geophysics and other techniques.

1969-1971 United States Army.

1972

1972-1975

1975-1976

South Dakota Geological Survey. Research Geologist. Involved in county groundwater program. Duties included mapping surficial Pleistocene deposits and identifying aquifers. Responsible for interpretation of geologic and hydrologic data as well as for supervision of drilling operations, electric logging, and other field investigations in the Missouri Coteau near Pierre, South Dakota. Initiated study to identify the occurrence and characteristics of the Codel sandstone, a principal water supply source in parts of the state.

Leonard Rice Consulting Water Engineers, Inc. Ground-water Geologist and Senior Hydrologist. Engaged in groundwater and surface water development projects including analysis of quantity and quality capabilities of individual aquifers. Supervised test hole drilling programs, aquifer tests, water rights investigations, and report preparation. Served as Project Manager for preliminary groundwater and surface water report describing the availability of water for energy-related development of Battlement Mesa. Developed runoff and snowpack correlations to estimate the surface water yields of ungaged basins in west slope Colorado and presented testimony in water and district courts for groundwater conflicts.

U.S. Geological Survey, Water Resources Division.

Project Hydrologist. Supervised investigations related to the occurrence, availability, and chemical characteristics of groundwater in coal-rich areas of Colorado. Participated in high plains groundwater studies and served as project chief on a Denver geologic basin study describing the availability of groundwater in the Arapahoe aquifer. Involved with the Bureau of Land Management's Energy Minerals Rehabilitation Inventory and Analysis to determine baseline conditions in parts of the state that were projected to be intensely mined. Developed reports on the water supply of the Southern Ute Indian Reservation and the geology and hydrology of the Arapahoe aquifer.

Robert E. Brogden (Continued)

1976-1980

Leonard Rice Consulting Water Engineers, Inc. Groundwater Geologist and Executive Vice President. Supervised studies involving test hole drilling, observation well installation, surface water and groundwater monitoring programs, and determination of regional and site-specific aquifer characteristics. Served as Project Manager on deep well construction projects for wells as deep as 2,300 ft. Described water rights and surface water and groundwater relationships for a large Colorado ranch. Developed technique by which natural groundwater contribution to consumptive use of crops could be quantified.

Directed hydrologic studies in western Colorado for numerous coal mine operations. Promoted development of natural geologic deposits as operating groundwater reservoirs. Conducted investigations in New Mexico, Utah, Colorado, and Wyoming to quantify groundwater stored in naturally occurring reservoirs. Provided expert testimony in district and water courts for groundwater conflicts.

1980-Date

Engineering-Science. Hydrogeologist. In charge of groundwater development projects, surface water investigations, and water rights studies. Involved in test hole drilling, well design and completion, analysis of aquifer quantity and quality capabilities, and presentation of expert testimony in water courts. Performed compliance review of mine plans for the Office of Surface Mining. Other projects include quantification of impacts of Federal Reserve filing on Wind River Reservation in Wyoming as well as impacts of minimum stream flow filings on proposed and existing surface water and groundwater rights and developments. Involved in soil and groundwater contamination studies at two semiconductor firms in California including examination of past waste disposal practices, establishment of a monitoring well and soil boring program to determine the extent of contamination, and development of an ameliorative program. Also participated in groundwater monitoring and soil sampling and analysis for development of remedial action and environmental restoration plans at several U.S. Air Force Bases.

Project Manager. Responsible for hydrologic studies for several coal mine operations in Colorado and neighboring states, including Colowyo Coal Company, Texasgulf Inc., Trinidad Coal Company, Empire Energy Company, and A. T. Massey, Inc. Supervised design and

Robert E. Brogden (Continued)

construction inspection of high capacity wells completed to depths as great as 2,500 ft with surface flows of 3,000 gpm. Managed study for Newmont Mining Services (a Magma Copper Subsidiary) to identify leakage from tailing ponds, direction of groundwater flow, and extent of groundwater contamination.

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STEPHEN L. DEERING

Sanitary Engineer

PII Redacted

Education

B.S. in Civil Engineering (Sanitary/Environmental Engineering), 1972, Tufts University, Medford, Massachusetts
 M.S. in Sanitary Engineering, 1977, University of California, Berkeley

Professional Affiliations

Registered Professional Engineer (California No. C 26514) American Society of Civil Engineers American Water Works Association Water Pollution Control Federation

Honorary Affiliations

Chi Epsilon

Experience Record

1970-1971	Haley & Aldrich, Inc., Cambridge, Massachusetts. Soils Lab Technician and Engineering Assistant. Performed shear, Atterberg limits, and consolidation tests.
1971	Herman G. Protze, Inc., Newton Highlands, Massachusetts. Concrete Inspector. Responsible for slump tests, preparation of cylinders, form and rebar examination, and safety requirements for large construction projects in Boston, Massachusetts.
1972	Lower Cape Foundation Company, Eastham, Massachusetts. Foreman of concrete construction crew and responsible for excavation, setting, and placing concrete house foundation footings.
1973-Date	Engineering-Science. <u>Project Engineer</u> . Involved with all phases of planning, report preparation, design, and specification, bid estimation, and construction supervision on water supply and wastewater disposal projects as well as inspection of sewer lines using

0183#

Stephen L. Deering (Continued)

air and water pressure techniques. Conducted extensive sewage collection system plan checking for subdivision development for a municipal sewer district and for design of sewerage collection and pumping systems. Involved in Greater Kathmandu, Nepal, Water Supply and Sewerage Project for spring and well domestic water source development and water treatment plants rehabilitation; designed 80 km of water and sewer pipe and coordinated aerial survey, soils testing, raw water and sewage pump stations design, and two sewage treatment plant designs. Assisted with the Clean Water Grant (PL 92-500, Section 201) project report and environmental impact report in San Diego County, California, which called for a sewer district planning study, a flow metering study, and design of a sewage package pumping station, force main, and a four-compartment, 20-acre percolation pond. Completed final review and coordination of plans and specifications for five sewage pump stations, 6.3 miles of gravity sewer and force mains, and a sewage treatment plant expansion for a sewerage consolidation project at Monterey Peninsula, California.

Senior Project Engineer. Shared responsibility for design of a 2.7 mgd Maryland City two-stage pure oxygen activated sludge sewage treatment facility including flow equalization, nitrification, solids contact phosphorus removal, mixed media filtration, ozone disinfection, gravity sludge thickening, anaerobic sludge digestion, and sludge filter pressing. Responsible for design of an 18-mile treated sewage effluent land outfall and plan checking sewage collection system designs for subdivision developments for the Fallbrook Sanitary District in San Diego County, California. Also responsible for application of safety and OSHA procedures required for maintenance of complete life support system as part of hazardous waste cleanup program at a U.S. Air Force base. Prepared process evaluation and design of solids handling and raw sewage equalization facilities for the Rancho Santa Fe pollution control plant expansion.

Involved in the World Bank funded Colombo, Sri Lanka, Sewerage Project including design of rehabilitation for 11 existing pump stations, 161 km of new force mains and sewers, 14 new pump stations, and two new 1,500-mm diameter ocean outfalls. Participated in retrofitting design of three raw sewage pump stations of 60, 80, and 100 mgd capacities for the Greater Bombay sewerage project in India.

Stephen L. Deering (Continued)

Project Manager (1979-Date). Developed a flood control plan for the City of San Marcos including preliminary channel design for capacity up to 7,400 cfs. Managed a water main relocation project for a section of new Interstate Highway 15 for Rainbow Municipal Water District. Supervised a water treatment and distribution system study investigating potable water quality, fire system adequacy and safety, and industrial water quality criteria at the U.S. Naval Ship Research and Development Facility. Responsible for contract administration for a sewage treatment facility expansion in San Diego County, California.

JEFFREY T. DeZELLAR

Civil Engineer

PII Redacted

Education

B.A. in Mathematics and Sociology, 1972, University of Minnesota

B.S. in Zoology, 1974, University of Minnesota

M.S. in Civil Engineering, 1978, University of Minnesota

Urban Planning, 1979-1980, University of California, Los Angeles

Experience Record

1974-1977

Minnesota Pollution Control Agency, Division of Water Quality, Roseville, Minnesota. Environmental Planner. Responsible for development of water quality management basin plans pursuant to Federal Water Pollution Control Act Amendments of 1972. Other duties included review of environmental impact documents for municipal wastewater treatment facilities, administration of the Construction Grants Program, and assessment of the potential for on-site sewage treatment for small communities.

1978-1979

Los Angeles County Sanitation Districts, Whittier, California. Project Engineer. Responsible for preparation of environmental impact report for a proposed wastewater treatment plant expansion in the Saugus-Newhall-Valencia area. Served as Project Manager for a study to develop mitigation or corrective measures for structural deterioration and hydraulic overloading in the districts' main sewer system.

1979-1980

The Conservation Foundation, Washington, D.C. Research Assistant. Performed engineering study of nonstructural and ecologically sound methods of runoff reduction and flood control. Identified management practices which promote natural percolation and storage of storm water.

1980-1981

U.S. Army Corps of Engineers, Los Angeles District, California. Project Manager. Supervised biological investigations related to flood control projects in Rancho Mirage and the Whitewater River. Also responsible for management of multipurpose flood control

Jeffrey T. DeZellar (Continued)

project for Goleta, California, emphasizing increased water supply, sediment control, and environmental enhancement of Goleta Slough. Developed preliminary restoration plans for Goleta Slough, initiated sediment sampling program for seven Goleta streams, and developed alternative flood control and water supply plans. Developed and conducted extensive public and agency involvement program.

1981-Date

Engineering-Science. Civil Engineer. Responsible for conducting engineering studies and assessments for hazardous waste disposal, including groundwater well installation and monitoring, evaluation of alternative waste handling systems, investigation of the fate and effect of hazardous materials, assessment of water and air quality impacts, and facility siting. Participated in development of cleanup programs for existing sites and control strategies for new facilities. Investigated potential groundwater and soil contamination associated with past hazardous waste disposal for a semiconductor firm and the U.S. Air Force.

Conducted engineering studies for a comprehensive solid waste management program for Orange County, California. Performed analysis and evaluation of the present landfill and transfer station system, the need for additional or improved facilities and equipment, present and projected waste quantities and composition, materials recovery, landfill gas recovery, waste-to-energy system, hazardous waste management, financial and institutional arrangements, and present and projected solid waste management costs. Performed engineering analysis of available solid waste quantities and traffic considerations for a co-disposal project for the Orange County Sanitation Districts.

Publications

"Effects of Water Conservation on Sanitary Sewers and Wastewater Treatment Plants," <u>Journal Water Pollution Control Federation</u>, Vol. 52, No. 1, January 1980, pp. 76-88 (Coauthor W.J. Maier).

"Benefits from Water Conservation Depend on Comprehensive Planning," Water Resources Bulletin, Vol. 17, No. 4, August 1981, pp. 672-677 (Coauthors W.J. Maier and R.M. Miller).

LENDA E. DOANE

Environmental Scientist

PII Redacted

Education

B.S. in Biology/English, 1972, Pan American University, Edinburg, Texas

Water Quality Management Workshop, 1973, Texas Water Quality Board, Houston, Texas

M.Ed. in Secondary Science Education, 1976, University of Houston, Texas

Professional Affiliations

Certified Environmental Study Area Leader (National Park Service, 1973)

Experience Record

1972-1979

La Porte Independent School District, La Porte High School, La Porte, Texas. Science Instructor. Developed and implemented classroom, field, and laboratory curricula in the physical sciences, general biology, field *Tology, vertebrate zoology, marine biology, and environmental science/human ecology. Sponsored student chapter of Earth Awareness Foundation, organized annual regional environmental symposium, and led field studies in various areas along the Texas Gulf Coast and in central Texas.

1980-1981

George C. Page Museum, Los Angeles, California. Museum Aide. Involved in preparation, restoration, identification, and cataloging of fossil specimens excavated from La Brea Pits and stored in the Hancock Collection. Performed microscopic examination of matrix for sorting and identification of microfossils.

1980-Date

Engineering-Science. <u>Environmental Scientist</u>. Participates in projects involving solid and hazardous waste management, air and water pollution control, and other environmental and engineering programs. Prepared RCRA contingency plan and personnel training program for W.R. Grace and Company synfuels plant in Kentucky. Evaluated sites for spent shale disposal

Lenda E. Doane (Continued)

for TOSCO and selected site based on various ecological criteria and archaeological significance. Conducted hazardous material spill notification and response investigation, evaluated Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) as well as other federal, state, and local hazardous waste control legislation, and edited reference handbook for hazardous waste management under RCRA. Participated in resource recovery/transfer system study for the Fresno-Clovis metropolitan area including assessment of environmental impacts and technological and economic evaluation of alternate transfer and recovery operations.

Responsible for data collection and analysis, identification of current and future hazardous waste generation patterns and disposal practices, regulatory analysis, and report preparation on a major waste management study for Orange County, California. Participated in project involving waste identification, site selection, and conceptual design of solid and hazardous waste disposal facilities for a proposed TOSCO oil shale processing program. Also involved in data collection and report preparation for hazardous waste studies at Edwards and McClellan Air Force Bases in California, Northrop Aircraft hazardous materials identification, development of Texaco groundwater monitoring plan, coastal water quality baseline study for a major South American petrochemical manufacturer, landfill methane gas migration and control system evaluation, and ecological study/wetlands evaluation of a hazardous waste disposal site for Shell Oil Company.

Papers and Presentations

"Symbiotic Relationships of Zooxanthellae and Certain Marine Invertebrates," presented at Seventh Annual Biology Seminar, Pan American University, Edinburg, Texas, October 1971.

"History of Medicine in Ancient Cultures," presented at Multicultural Education Symposium, University of Houston, Houston, Texas, November 1975.

"Cultural Assimilation and Ethnic Identity: Melting Pot or Salad Bowl?," presented at Multicultural Education Symposium, University of Houston, Houston, Texas, November 1975.

"Population Trends and Related Environmental Considerations," presented at Science Curriculum Development Seminar, University of Houston, Houston, Texas, April 1976.

Lenda E. Doane (Continued)

"Spill Response: Who to Notify?," presented at Industrial Waste Conference, California Water Pollution Control Association, Los Angeles, California, February 1982 (Coauthors J.L. Mang and F.R. Bowerman).

JANISE EHMANN, Ph.D.

Chemist

[PII Redacted]

Education

B.S. in General Science, 1965, University of Toledo, Ohio

M.S. in Reproductive Physiology, 1971, University of Toledo, Ohio

Ph.D. in Analytical Chemistry, 1976, Michigan State University, East Lansing

Electron Optics, Transmission Electron Microscopy (TEM), and Scanning Electron Microscopy (SEM), 1976-1977, Michigan State University, Lansing

Professional Affiliations

American Chemical Society
American Association for the Advancement of Science

Experience Record

1977-1978 Foster Farms, Livingston, California. Supervisor,

Chemistry-Nutrition Laboratory. Responsible for operation of nutrient analysis facility for major food processing company. Developed and conducted technical and operational training workshops for laboratory personnel. Also conducted independent research on

protein quality.

1978-1979 California Water Labs, Modesto, California. Super-

visor, Organic Residue Division. Responsible for development and operation of the trace organics division of a company providing comprehensive water quality analyses for government and industry. Established sampling, sample preparation, and analytical

procedures and trained laboratory staff.

1979-1981 Agri-Chem Analytical, Modesto, California. Owner.

Responsible for administration and management of a consulting laboratory specializing in analysis of soils, water, and chemicals for the agriculture/agri-

cultural chemical industries.

1979-1981 Valley Fresh Foods, Inc., Turlock, California.

Laboratory Manager. Responsible for the design and operation of a nutrient chemistry laboratory, as well

operation of a madriant chemistry laboratory

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Janise Ehmann, Ph.D. (Continued)

as for the training of all laboratory personnel. Conducted a feasibility study of the treatment, by-product recovery, and land disposal of industrial wastewater effluent for a new processing plant for the Department of Ecology, Olympia, Washington. Carried out a comprehensive in-plant waste generation and reduction study including analysis of daily water consumption and development of a water conservation program. Established light microscopy procedures for examination of certain feed ingredients.

1981

Environmental Research Group, Emeryville, California. Technical Director. Responsible for the efficient operation of an environmental testing facility engaged in providing research and development services to a wide variety of clients. Activities included the design and implementation of cost-effective research projects, training and supervision of laboratory personnel, and upgrading analytical capabilities of organic analysis division.

1982-Date

Engineering-Science. Manager, Laboratory Services. Responsible for supervising sample collection, preparation, preservation, and analysis for projects involving municipal and industrial water and wastewater treatment, water quality and soils studies, and hazardous waste contamination. Supervises quality assurance program maintained in determination of organic and inorganic analyses. Responsible for all special analytical determinations including gas chromatography and atomic absorption. Prepares designs and contract specifications for waste treatment laboratories.

Supervised analyses of soil and groundwater samples for various organic and inorganic hazardous constituents for a major semiconductor firm and for the U.S. Air Force at Edwards and McClellan AFB's in California. Also assisted with NPDES permit application and the monitoring of pollutants discharged under existing permits.

FRANK C. HEALY

Groundwater Geologist

[PII Redacted]

Education

B.A. in Geography, 1974, University of Denver, Colorado

B.S. in Geology, 1980, Metropolitan State College, Denver, Colorado

Professional Affiliations

Association of Engineering Geologists Associate Member) National Water Well Association, Technical Division

Experience Record

1974

U.S. Geological Survey, Environmental Geology Division, Lakewood, Colorado. Geologic Technician. Assisted in the compilation of geologic and land use maps of Jefferson County, Colorado, and Cape Girardeau, Missouri.

1977-1979

F. M. Fox & Associates, Inc., Wheat Ridge, Colorado. Geologist. Conducted engineering geology studies, groundwater investigations, water quality monitoring, and field investigations including geologic mapping, site evaluations, and test hole drilling, coring, and sampling. Prepared designs and operation plans for sanitary landfill and fly ash disposal sites. Performed investigation and prepared design for sewage disposal system along the Colorado Front Range.

1979-1980

Colorado Geological Survey. Ground Water Investigations Section, Denver, Colorado. Geologist. Responsibla for conduct of several geologic investigations concerning geothermal energy potential and groundwater quality in Colorado. Served as Project Chief for statewide groundwater quality mapping project and geothermal commercialization program.

1980-Date

Engineering-Science. Groundwater Geologist. Involved in a variety of hydrogeologic studies for municipal, Industrial, and agricultural clients. Serves as Project Hydrologist for groundwater development

Frank C. Healy (Continued)

studies and water resource and water rights investigations. Involved in pump tests, well design and inspection, hydrologic baseline studies, and report preparation.

THEODORE H. LUITEN

Construction Engineer/Estimator

[PII Redacted]

Education

- A.S. in Engineering Drafting, 1969, Citrus Community College, Azusa, California
- B.S. in Engineering Technology, 1976, California State Polytechnic University, Pomona

Professional Affiliations

Engineer-in-Training (California No. 38427)
American Society of Professional Estimators

Experience Record

1968-1972	Conrac Corporation, Duarte, California. Draftsman. Prepared mechanical and electrical drawings.
1972	Envirogenics Company, El Monte, California. Designer. Constructed and tested prototype reverse osmosis water systems.
1973	Kennedy Engineers, Inc., San Francisco, California. Draftsman. Prepared civil, electrical, piping, and structural drawings for sewage treatment plants.
1973-1976	Conrac Corporation, Duarte, California. Design Draftsman. Responsible for design and layout of electromechanical devices and printed wiring boards.
1976-1978	The Ralph M. Parsons Company, Pasadena, California. Cost Engineer. Responsible for cost control and fund allocation forecasting on a portion of the ARAMCO project.
1978	P. H. Luiten & Associates, Arcadia, California. Construction Manager. Involved in engineering and construction of light industrial buildings and similar structures.
1978-Date	Engineering-Science. Construction Engineer/Estima- tor. Responsible for preparation of construction cost estimates and contract administration during

construction for a variety of projects including

Theodore H. Luiten (Continued)

water, wastewater, and industrial waste treatment plants, sewage collection systems including inspection of sewer lines using air and water pressure techniques, and other environmental control facilities. Prepared preliminary cost estimate for San Luis Obispo Water Reclamation Plant.

Prepared definitive cost estimate for small hydroelectric plant in Alaska. Also prepared performance requirements and developed cost estimate for small hydroelectric installation at wastewater reclamation facility proposed for San Luis Obispo.

GORDON S. MAGNUSON

Civil Engineer

PII Redacted

Professional Affiliations

B.S. in Civil Engineering, 1942, Stanford University, Palo Alto, California

M.S. in Civil Engineering, 1956, University of Southern California, Los Angeles

Professional Affiliations

Registered Professional Engineer (Arizona No. 4188 and California No. 7673)

American Academy of Environmental Engineers (Diplomate)

American Public Works Association

American Society of Civil Engineers (Fellow)

American Water Works Association

Arizona Water and Pollution Control Association

California Water Pollution Control Association (President, 1970)

City and County Engineers Association

Nevada Water and Pollution Control Association

Structural Engineers Association of Southern California

Water Pollution Control Federation (Director, 1973-1976)

Honorary Affiliations

Chi Epsilon

Experience Record

1943-1946

U.S. Navy, Civil Engineer Corps. <u>Lieutenant</u>. Served as representative of Bureau of Yards and Docks on several advance base floating dry docks in South and Central Pacific. Responsible for insuring proper operation and maintenance of the vessel.

1946-1948

Chicago Bridge and Iron Company, Torrance, California. Construction Engineer. Supervised erection of steel structures and welded and riveted tanks for California refineries. Responsible for ensuring construction conformance to plans and specifications, making field design revisions, and maintaining limison with clients' engineering departments.

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Gordon S. Magnuson (Continued)

- 1948-1951 Los Angeles County Road Department, Bridge Division.

 Structural Engineering Supervisor. Directed the
 activities of structural engineers group in the design
 of rigid frame reinforced concrete and steel bridges
 crossing rivers in Los Angeles County. Participated
 in determining bridge locations and alignments. Maintained liaison with flood control officials and other
 government agencies and utilities affected by the
 bridge structure.
- Ralph M. Parsons Company, Los Angeles, California.

 Structural Engineering Supervisor and Project Engineer. Supervised structural engineering design of large complex installations on projects for the Atomic Energy Commission, U.S. Army, U.S. Navy, and U.S. Air Force. Served as Project Engineer for static test tower at Redstone arsenal and atomic energy facilities at Los Alamos, New Mexico.
- 1954-1955 Davidson Brick Company, Los Angeles, California.

 Provided consultation to architects and structural engineers for the design of reinforced brick masonry with particular emphasis on seismic considerations.

 Completely revised and updated a manual for design of reinforced brick masonry structures which is still used as a basic design reference by structural engineers in southern California.
- 1955-1967 Interpace Corporation, Clay Pipe Division, Los Angeles, California. Senior Applications and Special Process Engineer. Provided technical assistance to consulting engineers and municipal and district engineers in design of sanitary sewerage systems. Responsible for selection and development of all pipe products.
- National Clay Pipe Institute, Los Angeles, California.

 Vice President and General Manager of Western Region.

 Provided technical advice and information on pipe specifications and assistance to consulting and municipal engineers for design of sanitary sewerage systems. Provided major input and editing of Clay Pipe Engineering Manual used as a basic reference in sewerdesign. Participated in writing ASCE-WPCF manual of practice for design of sanitary sewers and storm drains and in developing various technical publications on sewer design.
- 1969-1974 Pacific Clay Products, Los Angeles, California. <u>Vice President</u>. Responsible for technical liaison, engineering coordination, distribution, and product

Gordon S. Magnuson (Continued)

development for all products manufactured by Pacific Clay. Served as a Director of the National Clay Pipe Institute and represented the company on numerous technical and professional committees.

1974-Date

Engineering-Science. Senior Technical Director (1974). Responsible for the development of project design criteria, supervision of projects, and technical monitoring and review. Provided technical consultation and coordination for the design of sewer interceptors and outfall lines and installation of pipelines requiring special structural considerations. Also provided special consultation regarding sulfide generation in sewer lines and application of mitigating measures.

Vice President and Regional Manager (1975-1980). Responsible for development of project design criteria, special consultation, technical review and coordination, and project administration and liaison.

Division Vice President (1980-Date). Responsible for directing the firm's civil and environmental engineering activities in the western U.S.

Publications

"How to Select a Consulting Engineer to Perform Gas Control Engineering Services," Workbook of the EPA/DOE Intergovernmental Methane Task Force, Denver, Colorado, March 1979 (Coauthor M. E. Nosanov).

Papers and Presentations

"Sewage Treatment Plant Design," Symposium Panel Moderator, California Water Pollution Control Association Annual Conference, 1969.

"The Hydraulic Properties of Tees Versus Wyes for Sewer Lateral Connections," presented at Arizona Water and Pollution Control Association Annual Conference, 1970.

"Site Investigation, Selection, Design and EIR for an Industrial Process Residue Facility Meeting the Requirements of a Class II-1 Disposal Facility," presented at California Water Pollution Control Association Southern Region Industrial Waste Conference Workshop, Los Angeles, California, January 1980 (Coauthor M. E. Nosanov).

"Methane from Combined Gas Control Venting and Recovery Systems," presented at Landfill Methane Utilization Symposium, Argonne National Laboratories, Asilomar, California, March 1980 (Coauthor M. E. Nosanov).

Biographical Data

JAMES L. MANG

Environmental Engineer

[PII Redacted]

Education

B.S. in Mechanical Engineering, 1973, University of Cincinnati, OhioM.S. in Environmental Engineering, 1974, University ofSouthern California, Los Angeles

Professional Affiliations

American Society of Civil Engineers Water Pollution Control Federation

Experience Record

1968-1973

The Timken Company, Canton, Ohio. Engineer Trainee. Responsibilities included drafting, product design, machine and machine tool design, quality control, and time study at a roller bearing factory and a steel mill. Also involved in labor relations, setting labor rate incentives, and facilities management. Developed a mathematical model for solid waste collection for Covington, Kentucky, and served as project manager for the design and testing of a waste incinerator.

1973-1974

University of Southern California Environmental Engineering Laboratory, Los Angeles, California.

Research Assistant. Responsible for the operation of analytical equipment including gas chromatograph, atomic absorption units, and spectrophotometer.

Designed and executed experiments to assess the environmental effects of disposal of dredged material in water and developed new techniques for measuring water quality parameters in sediment.

1974-1977

SCS Engineers, Long Beach, California. Staff Engineer (1974-1975), Project Engineer (1975), and Project Manager (1975-1977). Responsible for managing financial and personnel resources for a wide variety of environmental engineering projects including field, laboratory, and literature studies concerned with water pollution and land disposal problems with emphasis upon water and soil chemistry. Responsible

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for marketing, proposal preparation, and client development and liaison.

Managed several extensive studies on land disposal of dredged material for the U.S. Army Corps of Engineers Waterways Experiment Station. Projects included development and implementation of a field monitoring and sampling program for the physical and chemical characterization of dredged material sediments involving determination of the quality of interstitial water and leachates associated with active and inactive disposal areas. Conducted laboratory investigation of leachate composition and analysis of treatment techniques for application to leachates generated from disposal of different dredged materials to landfills and other types of land disposal sites. Performed literature review of state-of-the-art technology, environmental impacts, and economics associated with inland disposal of contaminated dredged material.

Other activities included groundwater well installation and sampling, design of landfill gas control systems, analysis of surface water and groundwater quality data, state-of-the-art review of health effects associated with wastewater and sludge disposal systems, and assessment of health effects associated with direct reuse of municipal wastewater. Prepared a study on the control of birds attracted to a sanitary landfill as a hazard to aircraft. Participated in the development of several areawide solid waste management plans, a nationwide project on groundwater impacts of municipal sludge disposal in landfills, and a national study of leachate from municipal sanitary landfills.

1977-1979

Calscience Research, Huntington Beach, California. Vice President. Responsible for federal government overhead negotiations, contract negotiations, marketing, and management of water pollution and land disposal projects including field and literature studies. Responsible for proposal preparation and client development and liaison. Projects included studies on the enhancement of biological treatment and sludge digestion of municipal wastewaters; environmental and public health effects of land disposal of wastes from coal utilization; treatment of industrial wastes from electroplating; leachates from sanitary landfills; and sanitary landfill disposal of sludges. Also prepared synthesis of laboratory and field investigations for the U.S. Army Corps of Engineers Waterways Experiment Station to evaluate potential water quality impacts associated with effluents and leachates generated

during confined land disposal in active and inactive sites.

1979-Date

Engineering-Science. Environmental Engineer/Project Manager (1979-Date). Responsible for direction of projects involving solid and hazardous waste management. Supervised hazardous waste cleanup programs at U.S. Air Force bases including groundwater monitoring, soil sampling and analysis, industrial wasteline investigation, and development of remedial action and environmental restoration plans. Managed soil and groundwater contamination studies at two semiconductor firms in California involving groundwater monitoring and soil sampling to determine the extent of contamination, and developed ameliorative programs to meet strict government agency regulations. Conducted resource recovery/transfer station system conceptual design study involving site selection and technical, environmental, and economic evaluation of alternatives for the Fresno-Clovis Metropolitan Solid Waste Commission. Also responsible for developing preliminary design of waste-to-energy system for Los Angeles Unified School District including evaluation of solid waste collection, transportation, and disposal operations, feasibility assessment of energy and materials recovery, and development of solid waste management plan.

Developed an ameliorative program for a municipal landfill which was polluting groundwater above one of only five sole source aguifers in the United States as well as a remedial action program for an industrial land disposal site operated by an aluminum producer above another of the nation's sole source aquifers. Devised hazardous waste management training program for aircraft manufacturing plant supervisors and developed legislative guidelines for hazardous waste facility siting for a major oil refiner. Identified hazardous wastes generated by a leading steel-producing company. Reviewed design of hazardous waste facilities for coal-to-ethanol-to-gasoline plant for major chemical company. Performed hazardous waste identification and evaluated storage, transfer, handling, and disposal operations for an aircraft manufacturing facility. Developed RCRA compliance monitoring program for semiconductor firm including waste analysis plan, facility inspection plan, contingency plan, training program, and employee testing manual.

Performed comprehensive technological and economic analysis and evaluation of EPA hazardous waste regulations including landfilling, landfarming, and surface impoundments for the Chemical Manufacturers Association. Responsible for conceptual design of hazardous and nonhazardous waste disposal facilities for oil shale processing for TOSCO including waste characterization, site selection, and development of operational plan for RCRA compliance. Supervised spill and chemical solvent tank cleanup including soil sampling and analysis, groundwater monitoring, aquifer testing, and cleanup and disposal operations for a major semiconductor firm under review of numerous federal and state agencies. Developed groundwater monitoring program for Texaco and conducted ecological/wetlands evaluation of a hazardous waste disposal site for Shell Oil Company. Also responsible for development of management plans for hazardous and nonsewerable liquid wastes generated within Orange County, California.

Editor and Lecturer (1980-Date). Responsible for developing and editing a reference handbook for hazardous waste management for industrial facilities. Serves as lecturer at public and industrial seminars on hazardous waste, with responsibility for lecturing on meeting RCRA requirements; design of hazardous waste treatment, storage, and disposal facilities; characterization of waste materials; and industrial facilities management.

1980-Date

California State University at Long Beach, California.

Instructor (concurrent position). Responsible for aiding in development of hazardous waste occupational and engineering training course sponsored by the U.S. Environmental Protection Agency. Teaches course segments addressing the design and operation of hazardous waste landfills, land cultivation sites, and underground injection facilities; sampling, analysis, and characterization of waste material; and industrial facilities management under RCRA.

Publications

"The Potential for Adverse Health Effects Associated with the Application of Wastewaters and/or Sludges to Agricultural Lands," Land As A Waste Management Alternative (Ann Arbor, Michigan: Ann Arbor Press, 1977) (Coauthors D. Weaver, W. Galke, and G. Love).

A Study of Leachate from Dredged Material in Upland Areas and/or in Productive Use, U.S. Army Corps of Engineers Waterways Experiment Station Report No. 2D02, February 1978 (Coauthors J.C.S. Lu, R.J. Lofy, and R.P. Stearns).

Physical and Chemical Characterization of Dredged Material Sediments and Leachates in Confined Land Disposal Areas, U.S. Army Corps of Engineers Waterways Experiment Station Report No. 2D05, May 1978 (Coauthors K.Y. Chen, K.Y. Yu, and R.D. Morrison).

Synthesis Report-Confined Disposal Area Effluent and Leachate Control, U.S. Army Corps of Engineers, Chief of Engineers Office, June 1978 (Coauthors K.Y. Chen and B.A. Eichenberger).

Evaluation of Potential Water Quality Impacts from Coal Utilization Solid Waste Disposal under the National Energy Plan, Energy and Environmental Systems Division, Argonne National Laboratory, July 1978 (Coauthors K.Y. Chen, B.A. Eichenberger, and J.C.S. Lu).

Reference Nandbook for Hazardous Waste Management, First Ed. (Berkeley, California: Engineering and Science Research Foundation, March 1980) (Editor-in-Chief and Coauthor).

Reference Handbook for Hazardous Waste Management, Second Ed. (Berkeley, California: Engineering and Science Research Foundation, July 1980) (Editor-in-Chief and Coauthor).

"Surface Impoundment of Hazardous Wastes," <u>Proceedings: Conference</u> on Hazardous Materials Control of the Hazardous Materials Control Institute, Baltimore, Maryland, August 1981 (Coauthors F.R. Bowerman and D.R. Anderson).

Papers and Presentations

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"Control of Groundwater Contamination from Sanitary Landfills: a State-of-the-Art Review," presented to the Eighth Annual National Groundwater Conference, Las Vegas, Nevada, September 1976 (Coauthors R.P. Stearns and D.E. Weaver).

"Monitoring of Confined Dredged Material Disposal Sites," presented to the Ninth Annual National Groundwater Conference, Boston, Massachusetts, September 1977 (Coauthor R.D. Morrison).

"Analysis of RCRA, Phase II," presented at Seminar on Revlewing RCRA Part A Permits and Phase II Hazardous Waste Plans, Engineering and Science Research Foundation, 5-6 November 1980.

"Conducting Technical Audits and Developing Hard Data to Meet RCRA Regulations," presented at Seminar on Reviewing RCRA Part A Permits and Phase II Hazardous Waste Plans, Engineering and Science Research Foundation, 5-6 November 1980.

"Plant Management Guidelines Under RCRA," presented at Western Metal and Tool Conference, American Society for Metals/Society of Manufacturing Engineers, Los Angeles, California, 23-26 March 1981 (Coauthor W.R. Kirkpatrick).

"Meeting Near-term RCRA Regulations," presented at Western Metal and Tool Conference and Exposition, American Society for Metals Society of Manufacturing Engineers, Los Angeles, California, 23-26 March 1981.

"How to Satisfy RCRA's Training Requirements," presented at National Hazardous Waste Conference, Engineering and Science Research Foundation, Chicago, Illinois, 7-8 April 1981; and at Hazardous Waste Management Workshop for Semiconductor Firms, Semiconductor Industry Association Engineering and Science Research Foundation, Santa Clara, California, 5 June 1981.

"Hazardous Waste Training Programs," presented at National Hazardous Waste Conference, Engineering and Science Research Foundation, Chicago, Illinois, 7-8 April 1981.

"Contingency Plans and Emergency Procedures," presented at Hazardous Waste Management Workshop for Semiconductor Firms, Semiconductor Industry Association/Engineering and Science Research Foundation, Santa Clara, California, 5 June 1981.

"Superfund Update (CERCLA of 1980)," presented to Los Angeles Regional Forum on Solid Waste Management, Long Beach, California, September 1981 (Coauthor P. Rogers).

"Types of Wastes and Disposal Systems," presented at Symposium on Hazardous Waste Management: Protection of Water Resources, Louisiana State University, Baton Rouge, Louisiana, 16-18 November 1981 (Coauthors D.R. Anderson and F.R. Bowerman).

"Spill Response: Who to Notify?" presented at Industrial Waste Conference, California Water Pollution Control Association, Los Angeles, California, February 1982 (Coauthors F.R. Bowerman and L.E. Doane).

"Cleaning Up Hazardous Waste Sites," presented at Thirteenth Annual Western Regional Solid Waste Symposium, Governmental Refuse Collection and Disposal Association, Buena Park, California, 28-30 April 1982.

11.75

Biographical Data

TOM K. MARTELLA

Hydrogeologist

[PII Redacted]

Education

B.S. in Geology, 1975, Fort Lewis College
Domestic Water Supply Planning, Water Well Technology, Hydrogeology, and Pump Service, Installation, and Selection, 1976, Fort Lewis College

Professional Affiliations

American Water Resource Association National Water Well Association

project.

Experience Record

1973	Amoco Minerals Corporation, Alaska. Assistant Field Geologist. Supervised geochemical and geophysical survey data collection on mineral exploration program for molybdenum and copper mine sites.
1974	U.S. Forest Service. Geologic Field Technician. Participated in project to locate and evaluate sites for potential gravel pit development for Forest Service road construction. Performed soil compaction tests, moisture content evaluations, and surveying duties.
1975 and 1977-1978	Rio Blanco Oil Shale Company. Geologic Drafter/ Illustrator. Prepared various graphic materials for Rio Blanco oil shale project reports and presenta- tions. Prepared site and process illustrations for magazines and brochures. Assisted in cross-section preparation, lithology, and preliminary mine con- struction calculations.
1978-1980	Wright Water Engineers. Project Geologist (1978-1979). Responsible for data analysis and interpretation, preparation and review of reports, and training of field personnel on Rio Blanco oil shale

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Tom K. Martella (Continued)

Hydrogeologist (1979-1980). Served as project engineer on various water supply projects. Responsible for well pump installation and selection, drilling supervision, controlled well pump tests to evaluate aquifers, and evaluation of field data. Participated in geophysical investigations, well design, groundwater quality and resource development studies, and hydrogeologic studies. Also prepared contract documents and well specifications. Major clients included Cyprus Mine Corporation and Utah International of Wyoming.

1980-1981

Camp, Dresser & McKee, Inc. Hydrogeologist. Served as drilling supervisor and field coordinator for large Mobil synfuels project in Montana. Responsible for piezometer installation and construction, aquifer testing and analysis, instruction and supervision of technical personnel, supervision of materials acquisition, and contracting of third-party services.

1981-Date

Engineering-Science. <u>Hydrogeologist</u>. Responsible for supervision of drilling, well pump installation, and piezometer installation and construction on a number of hydrogeologic and groundwater quality investigations. Projects include piezometer installation and drilling supervision for Sunedco in Utah.

Biographical Data

YANE NORDHAV

Hydrogeologist

PII Redacted

Education

B.A. in Political Science, 1974, University of Copenhagen
B.A. in Geology, 1976, University of California, Berkeley
M.Sc. candidate in Geology, 1983, California State University, Hayward

Professional Affiliations

Association of Engineering Geologists Association of Environmental Professionals Association of Women Geoscientists

Experience Record

1977-1980

Environmental Impact Planning Corporation, San Francisco, California. Geologist/Project Manager. Conducted geologic and hydrologic studies to evaluate adverse impacts of residential, commercial, and industrial developments. Responsible for evaluating effects on groundwater quality and quantity of converting 750 acres of prime agricultural land to residential use in Fresno County. Developed a water balance for the basin for existing and future conditions and estimated water quality impacts of installing septic tank systems in areas with a high water table and well-developed hardpan.

Supervised study of quantity and quality of available sand and gravel resources in Sacramento County, including an estimate of the cost-effectiveness of extraction versus importation. Conducted hydrogeologic investigation focusing on groundwater occurrence and movement, fault activity, and nature of soil material to determine suitable disposal sites for sludge generated in the San Francisco Bay area. Served as project manager for numerous environmental studies focusing on hazards from slope instability, settlement, subsidence, erosion, and flooding in California, Wyoming, and Nevada.

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Yane Nordhav (Continued)

1981-Date

Engineering-Science. Hydrogeologist/Project Manager. Responsible for hydrologic and geologic investigations supporting hazardous waste investigations and water resource development and groundwater management programs in a variety of geologic and hydrologic regimes. Activities include development of drilling programs, supervision of well installation, geophysical logging, and groundwater sampling for trace metals and organic analysis. Developed and supervised drilling programs to investigate potential groundwater contamination at Edwards AFB and McClellan AFB as part of the U.S. Air Force's Installation Restoration Program - Phase II. Directed installation and sampling of groundwater monitoring wells and completion of soil borings downgradient from suspected contamination sources to determine the extent of area contamination resulting from past waste management practices of semiconductor firms. Involved in a study of past material handling practices at Drew Manufacturing Company to determine surface and subsurface distribution of trace metals and the extent of soil contamination.

Served as project manager on field investigations and preparation of environmental impact reports concerning increased discharge of wastewater treatment plant effluent to the Santa Ynez River in Santa Barbara County, development of an area subject to severe flooding in Richmond, California, and proposed gold mining operations in Napa County. Also involved in major research and field demonstration project investigating the feasibility of irrigating food crops with treated wastewater. Duties include preparing reports on studies of aerosol generation and pathogen dispersion as well as interpreting water quality and physical/chemical soils data.

Biographical Data

JEFFREY L. RUBIN

Soil Chemist

[PII Redacted]

Education

B.S. in Soil and Water Science (honors), 1974, University of California, Davis

M.S. in Soil Science, 1980, University of California, Davis

Professional Affiliations

Certified Professional Soil Specialist, American Registry of Certified Professionals in Agronomy, Crops, and Soils (ARCPACS) American Society of Agronomy Council for Agricultural Science and Technology Professional Soil Scientists Association of California Soil Conservation Society of America Soil Science Society of America

Experience Record

1972-1979

University of California, Davis, California. Department of Soils and Plant Nutrition. <u>Laboratory Helper</u> (1972-1973) and <u>Laboratory Assistant I</u> (1973-1974). Assisted in research projects involving soils and plant nutrition. Determined the physical properties of farm animal manures using traditional soil testing techniques.

Department of Soils and Plant Nutrition. Laboratory Assistant II (1974-1975). Investigated the utilization of nitrogenous organic residues from agricultural wastes for energy and use of the remaining ash for crop fertilizer. Conducted closed system field study on the fate of applied fertilizer nitrogen. Research also included manure decomposition rate studies, effects of animal manure on soil crusting, greenhouse studies demonstrating plant response to manure ashes, and studies to determine plant-available phosphorus in ashed crop residue.

Academic Advising and Counseling. Resource Science
Advisor (1973-1974). Advised students on academic program alternatives and future employment prospects.

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Jeffrey L. Rubin (Continued)

1978

Agronomy and Range Science Department. Soil Scientist/Intern (1975). Surveyed and mapped the soils within the irrigated pasture fields of the University of California Sierra Foothill Range Field Station. The survey was used to prepare a comprehensive plan for the development, management, and experimental use of irrigated fields.

Department of Land, Air, and Water Resources: Soils Division. Graduate Research Assistant (1975-1979). Conducted research on the transfer of trace metals in the food chain and their potential hazard to the public.

Department of Engineering. <u>Laboratory Consultant</u> (1978). Responsible for performing chemical analyses on soil test samples to determine sulfate-sulfur content.

Department of Land, Air, and Water Resources: Soils Division. Staff Research Associate (1979). Served as project manager for salinity study of the San Joaquin Delta. Responsible for laboratory analyses of organic soils as well as data management.

- 1974-1975 Department of the Interior, Bureau of Reclamation,
 Division of Water and Land Operations (Recreation and
 Wildlife Resources Branch), Sacramento, California.
 Resource Specialist/Intern. Compiled environmental
 - data on outdoor recreation areas in California for a total management study of the Central Valley.
 - Sacramento Area Consultants, Sacramento, California.

 Field Consultant. Responsible for conducting a soil survey emphasizing soil susceptibility to permeability. Performed site evaluations for the Sacramento Regional County Sanitation District's proposed sludge application and management plan.
- 1979 California State Department of Conservation, Sacramento, California. Graduate Student Assistant.

 Responsible for coordination and reproduction of base maps, analysis of survey questionnaires, soil problem studies, and preparation of a report assessing statewide soil problems.
- 1979-Date Engineering-Science. Soil Chemist. Responsible for managing laboratory personnel, coordinating field sampling and laboratory analyses, and performing soil and tissue tests on projects utilizing wastewater for irrigation of agricultural land. Developed entire

Jeffrey L. Rubin (Continued)

field sampling programs for water and soils which included arranging for drilling subcontractors, establishing technical procedures, developing precautionary measures for sampling such as prevention of sample cross-contamination, and developing criteria for the well drilling and sampling activities. Project manager for all laboratory work for the Monterey Wastewater Reclamation Study for Agriculture, with responsibility for data management, statistical evaluation, and quality assurance for laboratory analyses performed by involved personnel.

Coordinated the development and performance of laboratory and field sampling procedures for soil and water assessments of hazardous wastes and conducted extraction tests utilizing EPA and California Department of Health Services methods of extraction and analysis. Directed laboratory studies examining the mobility of trace metals under various environmental conditions as part of a soil contamination investigation performed for a precious metals stripping facility. Developed an innovative soil sampling device to allow undisturbed extraction of potentially hazardous materials, particularly volatile hydrocarbons. Supervised field studies and laboratory analyses of contaminated soils and groundwater for semiconductor firms. Other major projects involved groundwater monitoring and analysis for priority pollutants; sampling and analysis for metals, PCBs, TCE, fluoride, and organic solvents, consisting of phenol, sulfonic acid, aromatic solvents, and chlorinated benzene; and field monitoring and analysis for dye tracing studies which simulate point source pollutant discharge. Served as liaison between clients and the California Department of Health Services in dealing with possible priority pollutants by coordinating field sampling programs and requirements with the state and participating in mutual on-site sampling efforts and splitting of samples. Promoted the firm's involvement with the hydrological aspects, sampling, and analysis of hazardous wastes for those projects requiring recommendations for further sampling and for groundwater monitoring.

Publications

"Physical Properties of Farm Animal Manures," <u>California Agricultural Experiment Station Bulletin</u>, No. 867, University of California - Division of Agricultural Sciences, November 1974 (Coauthors A.A.R. Hafez, J. Azevedo, and P. R. Stout).

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Jeffrey L. Rubin (Continued)

An Interpretive Survey of Some Irrigated Pasture Soils of the Lower Foothills of the Sierra Nevada Mountains of Northern California (University of California, Davis: Department of Agronomy and Range Science, Water Resources Center, 1975) (Coauthor C. A. Raguse).

"Phosphorus Fertilizer as a By-Product of Energy Production from Agricultural Wastes," <u>Journal of Environmental Quality</u>, 1977 (Coauthors R. Siegel, A. Hafez, and P.R. Stout).

California Soils: An Assessment (State of California: Department of Conservation, Soil Resources Protection Unit - Resources Agency, 1979) (Coauthors B. Brown, E. Craddock, B. T. Beutenmuller, T. Irving, S. Anderson, D. Stanley, and P. Vonich).

Papers and Presentations

"Comparative Chemical Effects of Organic Versus Inorganic Metal Salts Incorporated into Soil," M.S. Thesis, University of California, Davis, California, 1980.

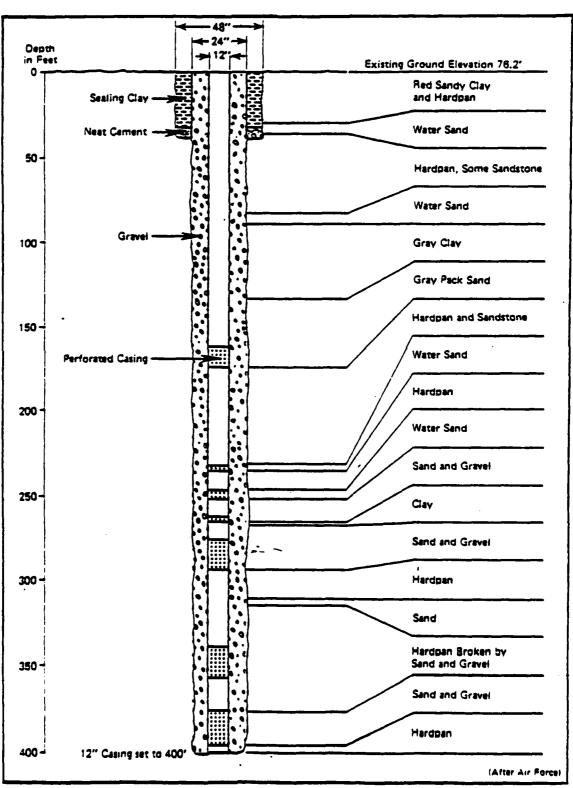
APPENDIX C

WELL DESIGNS AND WELL LOGS BASE PRODUCTION WELLS

WELL CHARACTERISTICS FOR BASE PRODUCTION WELLS
McClellan AFB, California

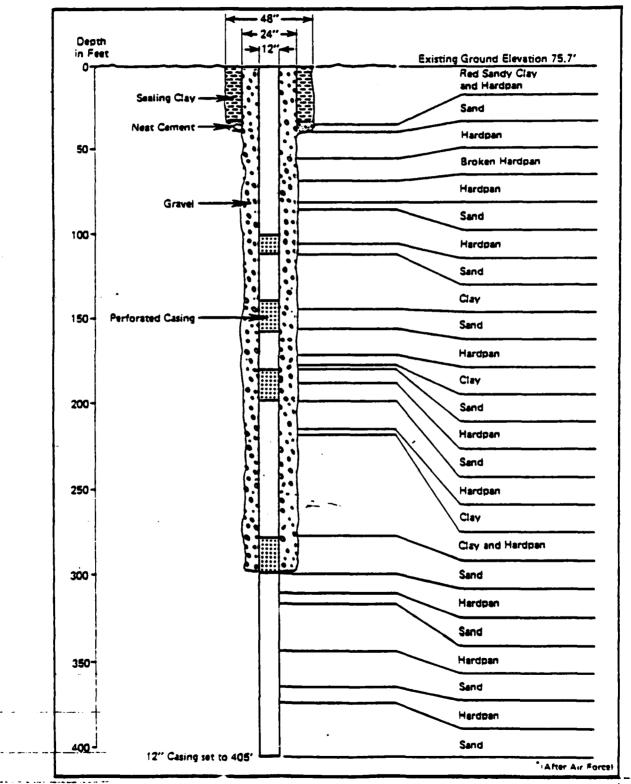
Base Well	Casing Depth (feet)	Perforation Locations (feet)	Depth of Gravel Pack (feet)	Grout Seal (feet)	Casing Diameter (inches)
1	400	162 - 174 232 - 252 247 - 252 266 - 268 274 - 292 340 - 354 376 - 396	0 ~ 400	0 - 36	12
2	298	100 - 112 141 - 158 180 - 197 282 - 296	0 - 298	0 - 40	12
7	398	170 - 398	0 - 398	0 - 50	12
8	625	None	0 - 625	0 - 50	12
10	400	170 - 392	0 - 400	0 - 50	14/10
11	400	154 - 346	0 - 400	0 - 50	14/10
12	390	164 - 390	0 - 390	0 - 50	14
13	391	178 - 300	0 - 391	0 - 50	14/12
17	353	216 - 224 286 - 294 302 - 312	0 - 353	0 - 50	14
18	400	169 - 185 210 - 260 304 - 349 378 - 387	0 - 400	0 - 50	14
20	600	178 - 190 234 - 274 338 - 374 494 - 506 564 - 598	0 - 600	0 - 50	14
28	247	None			8
29	604		0 - 604	0 - 50	

BASE PRODUCTION WELL BW !

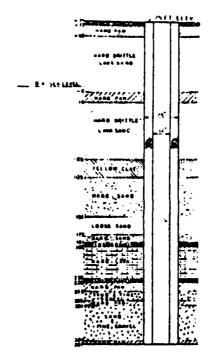


1-as-

BASE PRODUCTION WELL BWZ

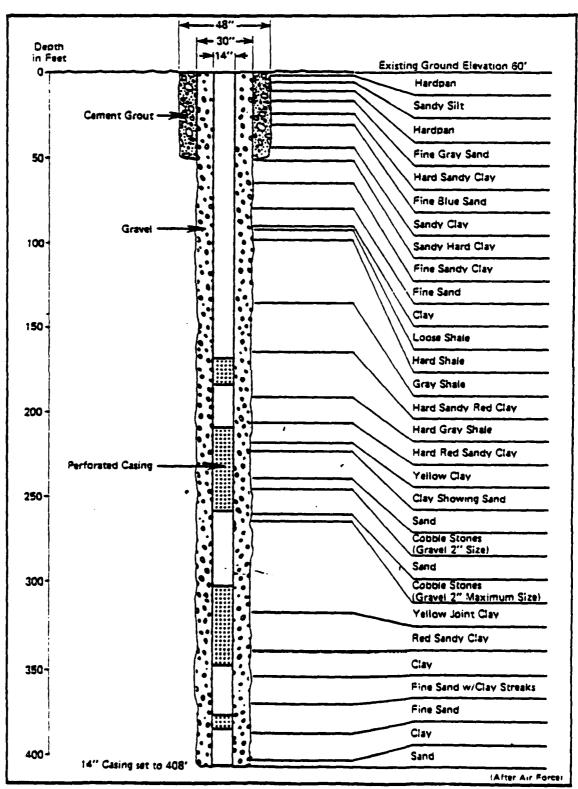


BASE PRODUCTION WELL BW8



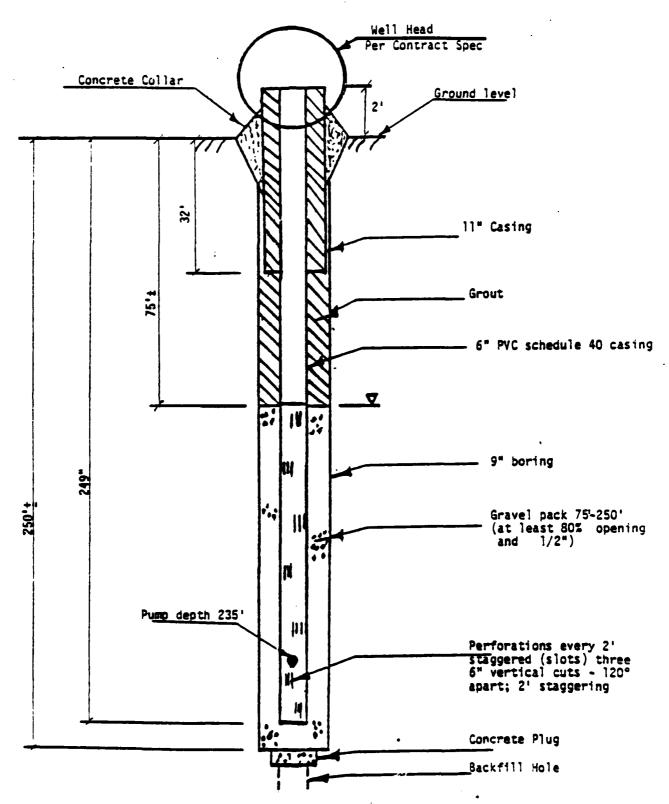
12" CASING

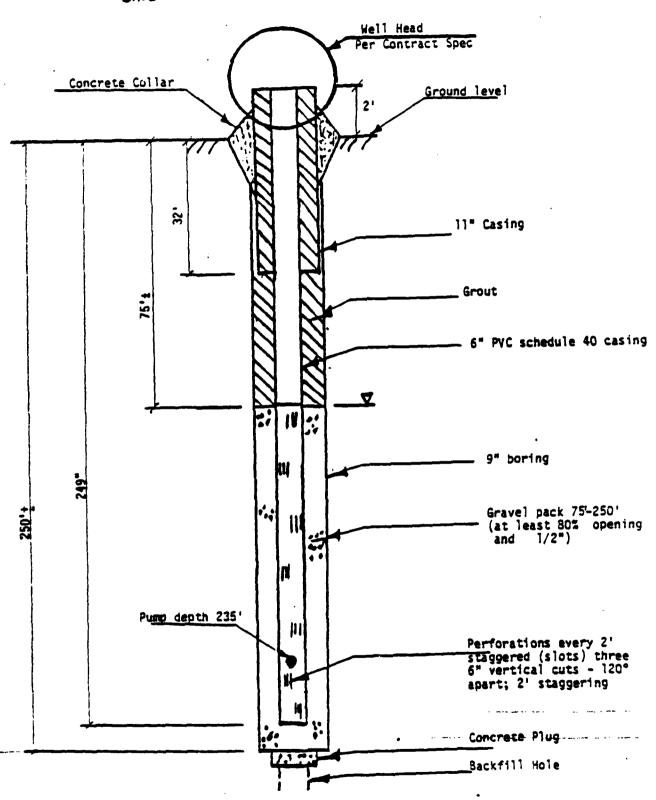
BASE PRODUCTION WELL BW 18



APPENDIX D

WELL DESIGNS AND WELL LOGS BASE MONITORING WELLS WELL DESIGNS
BASE MONITORING WELLS



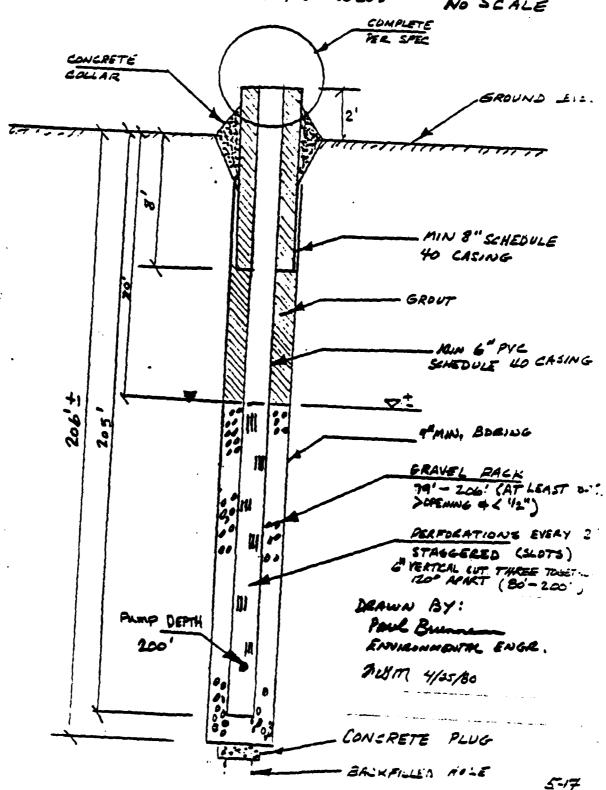


LOCATION OF WELL PERFORATIONS
CONTEACT NO. FO 4699-80-60205

WELL NO: 3.

DATE: 25 APRIL 80

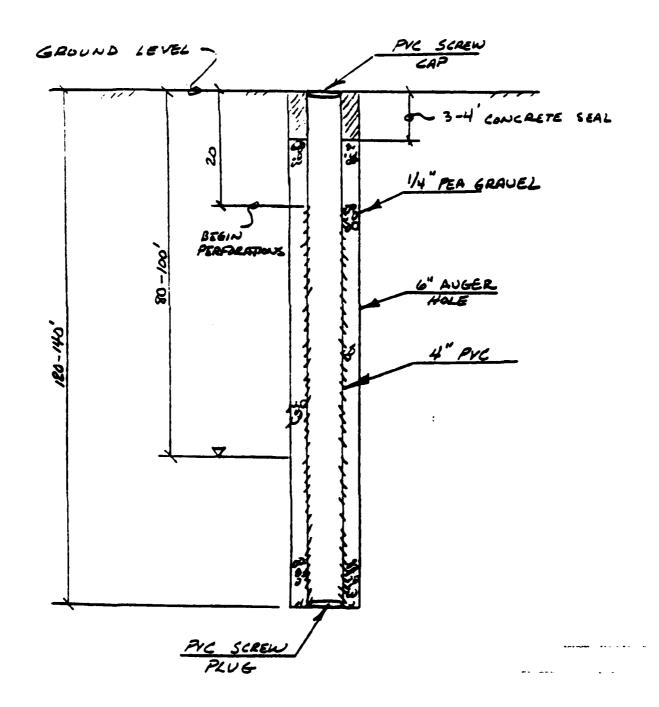
NO SCALE



WELL No: 4 DATE : 25 APRIL SO LOCATIONS OF WELL PERFORATIONS CONTRACT NO. FO 46 99-80-60265 NO SCALE CONCRETE COLLAR GROUND ILLE-MIN 8" SCHEDULE 40 CASING GROUT 98 MIN 6" PYL SINEDULE 40 CASING ♥\$_ ı, m -9"MIN BORING PREPARTIONS EVERY L'STAGGERED CSLOTS) L'VEETILAL CUT THE: DESTREE 120 MART. (15-240) FRANEL PACK (AT LEAST 80% > OPENING & Pumo DEPTH 230 u Deamy By. Paul B. Br ENVIRONMENTAL ENGE. Gare mem 4/25/80 CONCRETE PLUG 5-24 BACKERLED HOLE

Ł.

BASE MONITORING WELLS MW 5, 6,7,8,9



WELL LOGS BASE MONITORING WELLS

Defiling log for boreing #1 Contract #304699 80 00205 204699 60 00209 11 29, 1980 (Copy 5-7-80) On Monday April 21, hauled approx. 5000 gallons water and mixed 12 sacks and to get a seal on mud pit. Mixed mud (6 sacks) started drilling about 27 m (steel, bolders plastic, switches) so changed to solid augers and at 27 feet soil changed to black comtaminated sand of some sort. Took a grab sample and notified office at Jomit Persons notified—Fr. Clark, H.3. Frianged Paul Brunner.
Wed. april 23
Set caseing to 32 feet (Contaminated sand to 24 feet). Hole crooked because or all the steel in the hole, mixed 6 sacks mud.

Thur invil 24

Caseing leaking had to dri I along side caseing and ground mixed another as Type of soil

Samples taken at intervals

see flove

silty sand with trace of clay

silty sand

silty sand

silty sand

dence silt

dence silt partly cemented in layers

Dence silt partly cemented in layers

Clay

Samples taken at intervals

60'

70'

dence silt

Comples taken at intervals

60'

70'

100'

100'

80'

100'

80'

100'

100'

80'

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1 . Dim Exces Protage 10 to 45 45 to 60 60 to 70 to 80 3C -to 90 SC to 90
SC to 100
Dence silt partly cemented in layers
100 to 108
Clay
100 to 116
Sand
L to 130
Clay
120', 130'
130 to 168
Sand
150
168 to 175
Silt
175 to 200
Clay silt
200' 203 to 212 220 dence 255 sand silty clay 12 to 220 silty sand 263 to 270 silty clay
silty sand 270 to 281 281 to 287 to 292 sand 29? to 298 clay sand 193 to 320 121 to 348 143 to 354 156 to 370 170 to 389 silty clay said clay sand clay sandy silt

ALL TERRAIN Exploration Drilling 2789 Liberty Lene Roseville, California 95678

Drilling Log for bereing 32 Contract 8304699 80 00205 April 18, 1980

	•			
Tootage	type of soil	Semples	taken at Int	ervels
0 to 10	2:71	•		
10 to 201	gzriage			: · .
20 to 40'	silty send with clay		·40	1.
45 % 60 %	silty sand with trace of gra-	79]	50 75	1
50 to 751	sand with trace of gravel		75	•
75 50 251	dense silty sand			
25 10 11.71	clay	•		
117 to 1251	dence clay		- 190	•
	dence slay		• * •	•
11 to 1461	clear sand-lost approx. 1000) rallions mud	in Formation	-
149 to 150	clay sand	•	150	•
150 to 175	clean silt; sand	•	175	
175 to 184'	Silty clay			
	dence clay			- -
198 to 2001	sand		- 200	1
200 to 2231	clay silt		•	•
5 to 2501	clay silt		250	•
0 to 2601	sandy silt	: .		• •
260 to 2701	clay sand	•		- ,=
270 to 3001		, ,	500	•
300 to 310'	silty sand	•		
710 to 3291	cemented sand with layers of	cemented .		•
	clay silt.			
329 to 3471			••	• : •
	silty sand .			• • •
761 to 4001	silty sand with some cementic	or.	400	· -
-	•	• .	•	• • •
will thon so	sel caseing set to 30'.		8	

Cofe 5-2-80

pathatica ipril 14, 7	n grander of the 3 department therefore as notices.	, 5MA-129-5
Jon toge	Type of will a second to the less to	the of themsia
	fill gravel, black top	
	cement in wilty wand	
4 to 201	cilty sand ith layers of cemented	00.4
00 += 101	silt and clay	201
20 to 40'	Silty mand with alternating layers of cemented silt and clay	
40 to 50'	elltw sand	50'
50 to 90'	clay send .	75'
90 to 105'	sand	100'
105 to 145'	silt	125'
145 to 160	sand	150'
.160 to 190	sand (lost mud-no return 7 sacks mud)	175'
190 to 198'	Silt	2001
-198 to 204' 204 to 208'	gray sand	200
	sand with cemented layers	
235 to 251'	commented silty clay	
251 to 254'	sand with cemented layers	250 '
254 to 261'	dence silty clay	
261 to 300'	dence silty clay	300 '
100 to 3041	SENCY CLEY	
04 to 320' 320 to 330'	dence sand	
	dence silty clay with some layers of	
220 00 212	sand cemented	
373 to 400'	cemented silty clay with some sand	4001

ALL TERRAIN Exploration Drilling 2789 Liberty Lanz Roseville, California 95678

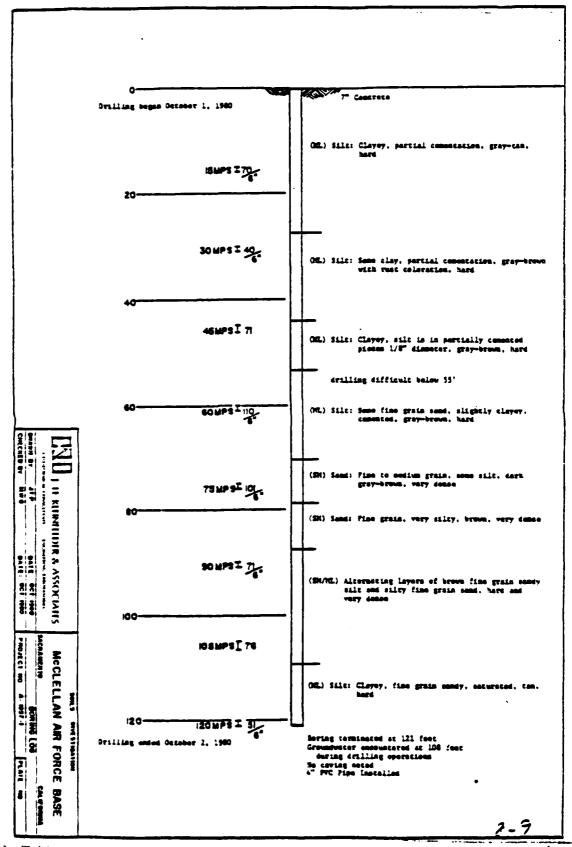
DRILLING LOG FOR BOREING #4 CONTRACT FF04699 80 00205 April 3, 1980

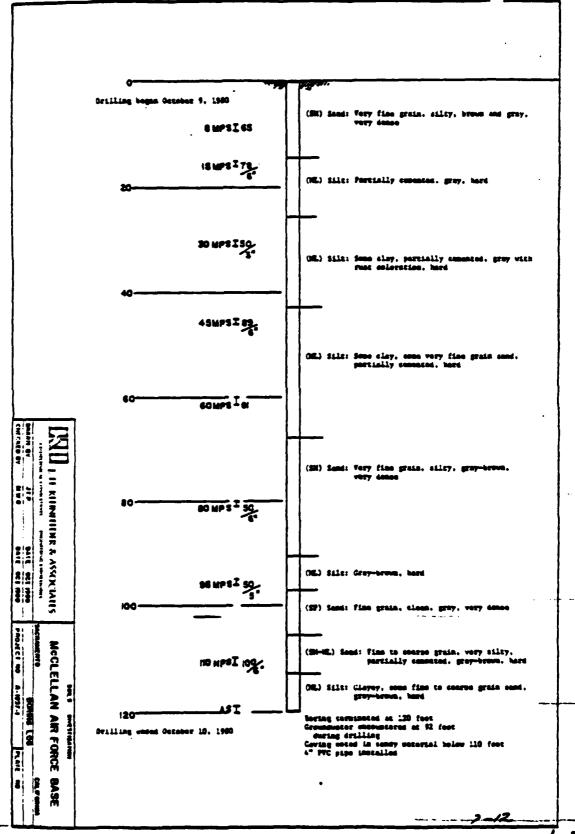
Pootage	Type of soil	Samples taken at intervals
0 to 45'	sand .	201
45 to 55'	clean sand	501
55 to 60'	trace of light gravel	
60 to 95'	dense clay sand	75'
95 to 120!	clay silt	100'
120 to 142'	silty clay with trace of gravel	125'
142' to 148'	_	
J.48 to 151'	silty clay	150'
151 to 168'	silty sand	
168 to 178'	sandy silt	175 '
-1.78 to 180'	lightly cemented	213
80 to 201 '	sand	200 '
201 to 209'	clay silt with trace of gravel	·
209 to 220'	sand . •	
220 to 225'	dense sandy silt	
225 to 230'	silty sand	
230 to 248'	sand	
248 to 282'	silt	250 '
282 to 288'	silty clay	
288 to 293'	dense hard clay almost rock	
293 to 3601	dense silty clay	300 ¹
360 to 400'	dense silty sand with trace of clay	
400 1	bottom of boreing	400 *

7-a68

Segus erilling 9-23-60	IG
	grades less clay 5 becomes green-brown pertially command
	30
	SOM PS_53 (SV) sand: fine to medium grain, dense, tam with black ofreads
	65M° 9I 66 (ML) sile: very time grain samey, hard, res-brown
	80 80MP \$ I 53 (SW) send: fine to endium grain, seem silt, dense, brown-tan
A SSC & BKIIIMAIIN A SSCK	9SMP9 I 75 (SH) send: fine grain, silty, bard, partially commented.
AIS	ING ING MFS I SO (NE.) silt: clayer, very fine grain sendy, hard, gray-can
LELLAN A	120 IZOMP'S TEE
NR FORCE BAS	130
BASE	Soring terminated at 10° 9-24-40 Groundwater encountered at 15° So caving notes. PVC Pipe installed. 8-6

O MANAGE
Begin drilling 9-25-40
STT2!" (SC) sand: fine to medium grain, soon clay, red-brown with gray streaks, medium dense
20
(NE.) silt: clayer, trace of fine grained send, gray-srown
VLER FRAC-SETTAKE, hard
30 30 M PS I 36
40
45MPS[39
(SHO sand: fine to medium grain, silty, gray-can with black & ruck streams, medium dance
grades lose silt
60 60MPSI30 (ML) silt: wery fine grain samey, red-brown with black
(CL) elsy: stity, partially commands, gray-brown, hard
(NE.) silt: clayer, melec, red-brown, hard - 75MPS ISO (SR) send: fine to medium grain, silty, can, conse
i -
(CL) clay: Silty, some fine grain send leases, gray, hard
Single Colors and colo
11 2
(SN) sand: fine grain, some salty and clay, brown, very dense
- i
(CL) eley: stity, some fine grain send leases 1/4" thick, tam; hard
(CL) eley: silty, seen fine grain sand leases 1/4" thick, tan; hard 180 180 MPS I 50 1
120 120 HP3 I 30 HP3
Boring terminated at 121.3' 9-24-40 Groundneter encountered at 19: No caving meted. PTC Pipe immended.
To caving metal. PTC Pipe imetallee.
ACE BA
al 's SS





			, which constitutes the
	<u>Depch</u>	ANNA AN	
	0	,,,,,,,	(ML) SILT: Fine grain sandy, tan, very stiff
			(RL) Sill: Fine grain sammy, can, very still
			11
			(SH) SAND: Fine to medium grain, silty, some clay,
	20'		brown, dense
		20 MPS T 60	(ML) SILT: Some fine sand, some clay, weakly cemented. (SM) SAND: fine to medium grain, silty, some clay,
			brown, dense
		30 MPS <u>T</u> 33/6"	
	٠٥'		(M) SILT. Blac area and and alex area.
	-	40 MPS T 32/6"	(ML) SILT: Fine grain sandy, some clay, weakly comented, tan, hard
		50 MPS] 54	(SM) SAND: Fine grain, silty, gray, dense
	60'		(ML) SILT: Fine grain sandy, clayey, gray, hard
		60 MPS I 50/6"	
ONE DATE OF THE OFFI			 -
CECHECHAND OV.		70 MPS] 31/6"	(SP-SM) SAND: Fine grain, some silt, gray, very dense
			:
T. KIEIN	80'		
H. KLEINFELDER & AS		30 MPS I 40/6"	
DER.			
A AS		90 MPS T 40/6"	(ML) SILT: Very clayey, weakly cemented, tan, hard
			(CL) CLAY: Very siity, weakly comented, gray, hard
SOCIVIES	100'		not
3		100 MPS T 30/6"	
HC CLELLAN	SUPPLIES	/SERVICES - SUMMARY	Soring terminated at 105', 7-27-81. Groundwater initially encountered at 80' during drilling
S TO T	Item Number	Quentity	7-27-81. Groundwater measured at 76' on 7-28-81. 107 feat of 4" Schedule 40 pvc pipe installed on 7-28-
8 9	0001AA	50 feet	Note: The stratification lines represent the approximate boundary between soil types and the transition
	0001AE	55 feet 3	eay be gradual.
BORING LAN AIR	0001AF	6	
PORTING LOG CLEILAN AIR FORCE BASE	0001AI 0001AJ	107 feat 105 feat	
NOE BA			
8 E 8			
CALIFORNIA			
<u> > </u>			

	<u>Depth</u> O	~ ent voc	-		FILL:	Matrix composed of clay, silt and send with pieces of pipe, metal, paper and glass, no apparent evidence of chemical odor
	20.	20 MPS] 6	-	(SM)	SAND	: Fine to medium grain, silty, black, loose
		30 MPS T 50		(SM)	SAND	: Fine grain, some silt, tan, dense
	40'	40 xps T 40/6"	-	(ML)	SILT	: Some clay, weakly cemented, light tan, hard
		50 MBS I 57	F	_		: Fine grain, some silt, light brown, dense : Some clay, weakly comented, tan, hard
0121]	60' <u> </u>	60 MPS I 69	-	(SH)	SAND:	: Fine grain, silty, brown
Name of the state		70 MPS] 50/4"	*	(ML)	SILT	: Some fine grain sand, some clay, weakly cumented, gray and brown, hard
H. KIEINEEDIR & ASSO	60. —	90 XB2 I 32/6	- 7	(HIL)	SILT	: Some fine grain send, some clay, tan, hard
		90 MPS [60				
3 3	100. —	100 HPS [47	-	(\$4)	SAMD:	Fine to medium grain, relatively cleam: gray-brown, medium dense
PROJECT NO	SUPPLIES	/SERVICES - SUMMARY Quantity		7-24-	dwate -61. unter	minated at 105', 7-24-81. It initially encountered at 79' during drilling Groundwater measured 10 minutes after initial and level rose to 74'. If 4" Schedule 40 pvc pipe installed on 7-24-8
DORING LOC CALLAN AIR PORCE BASE CAL	0001AA 0001AE 0001AF 0001AI 0001AI	30 feet 33 feet 3 6 107 feet 105 feet			The boun	stratification lines represent the approximate dary between soil types and the transition be gradual.

	Depth					
	0	W WAY	4	(CARA		
			Ш	(SE)	SILT:	Some fine grain sand, tan, very stiff
			П		•	
				(1477.)	e TT 4.	Sandy, clayey, red-brown
				(114)	3161.	Jamy, Clayey, reg-brown
			Ш		_	
	20' —	20 MPS] 70	-[]	(ML)	SILT:	Some fine grain sand, weakly cemented, gray, hard
			H		•	3.07.
		_				
		30 MPS ∑ 82		(ML)	STLT:	Fine grain sandy, clayev, gray, hard
	40'		┌┤		•	
	-	40 MPS 🗓 35]			
	•		$\downarrow \downarrow$	(SW)	SAND:	Fine to medium grain. relatively clean.
		50 MPS [45				gray, dense
			μ		,	
	60' -		_			
· · · · · · · · · · · · · · · · · · ·		60 HZS I 50/5"		(ML)		Some fine grain sand, weakly communed, gray, hard
2 2			Ц			
No bimera		70 MPS] 50/5"	11			
		-	$\ \cdot\ $	(ML)	ill:	Clayey, gray, hard
			Ш			
H. KLEINITLDIR & ASSI	80' -	80 MPS [79	• [Ac- \		
		** • <u>*</u> */		(HL)		Some clay, trace fine sand, tan and rust coloration, hard
J. F			1		•	
R & ASSO		90 MPS T 50/6"				
				(SM) :	AND:	Fine grain, silty, gray, very iense
OC 1VII 2	1001		} }			
5	100' -	100 Mg/S [30/3"		(CL) (LAY:	Silty, some fine grain sand, gray, hard
SAC			Ш			• • • • • • • • • • • • • • • • • • • •
NC CI,ELLAN SACRAMBATO	SUPPLIE	S/SERVICES - SURPLARY		Ground 7-22-6	water	instead at 105'. initially encountered at 37' during drillin
ਰ ਰ ਜ	Item Number	Quantity		107 fe	et of	4" Schedule 40 pvc pipe installed on 7-23-8
CO.	0001AA 0001AB	50 feet		Note:	The s	tratification lines represent the approximat
BORING	0001AE	55 feet 3			bound	ary between soil types and the transition a gradual.
	0001AF	6			_, -	-
Toget	1A1000 LA1000	107 feet 105 feet				
2 2	444 100	703 1445				
8 5 E						
CALI FORMIA						

	Depth		
	0		
		10 MPS <u>T</u> 79	(SM) SAND: Fine grain, silty, gray and brown, medium dense
·	20	20 MPS [50/5"	(ML) SILT: Commenced, gray, hard
		30 MPS T 50/4"	(ML) SILT: Some fine grain sand, gray, hard
	40' _	40 MPS I NC	
		50 HPS [50/5"	(SM) SAND: Fine grain, silty, brown
	60' <u>-</u>	60 NOTS] 50/6"	(SN-HL) Alternating layers of silty fine grain sands and weakly cemented clayey silt
Consume a		70 MPS] 74	(ML) SILT: Some clay, some fine grain sand, brown, hard (ML) SILT: Some clay, gray, hard
N. KI EINEEL	so	80 MPS [55/6"	(ML) SILT: Fine grain sandy, some clay, gray
DER & ASSO		90 MPS <u>I</u> 76	(SP-ML) Alternating layers of fine grain sand and silt
SOCIAIES	100' _	100 MPS] 70/4"	(ML) SILT: Fine grain sandy, brown (ML) SILT: Some clay, commented, brown, hard
PROJECT NO. A.1852.2 PAGE SACRANENTO	SUPPLIE Icon Number 0001AA 0001AB	S/SERVICES - SUMMART Quantity 50 feet 55 feet	GCL) CLAY: Silty, some fine grain sand, brown, hard Boring terminated at 103', 7-15-81 Groundwater initially encountered at 78' during drilling 7-15-81. Groundwater eastured at 78' 3" one hour after completion of drilling. 107 feet of 4" Schedule 40 pvc pipe installed on 7-15-81. Note: The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
IR FORCE BASE CALIFORNIA	0001AF 0001AF 0001AI	4 6 107 feet 105 feet	•

	Depth		
• •=	0	-///////	7 P
			(ML) SILT: Fine grain sandy, some clay, gray and brown
		-	}
		10 MPS] 58/4"	
			(ML) SILT: Weekly comented, piece 1/4" size break under finger pressure
	20' -	20 MPS [52	
		20 mg [32	(SH) SAND: Fine grain, some silt, gray, dense
			
		30 MPS [53	1 1
			1 (
			(SM) SAND: Fine grain, some silt, brown, dense
	40' -		<u> </u>
		40 MPS [33/3"	(NL) SILT: Some fine grain sand, weakly commenced,
			brown, hard
		50 MPS T 50/5"	
		20 HES T 2012	(ML-SM) Alternating layers of fine grain sandy silt
			and silty fine grain sands
	60'		 -
		60 HPS] 35/6"	(NL) SILT: Weakly comented, tan and rust-brown, hard
9			
PACTOR PA		T -	slower drilling below 62'
		70 MPS T 42	· ·
		•	(SM) SAMD: Fine grain, some silt, gray, dense
H. KIEINIELDER & AS	80' -		
THE PARTY		80 MPS I 47/5"	-
R & AS		T	 -
<u> </u>		90 MPS I 50/6"	(ML) SILT: Comenced, light gray, hard
SOCIA			1 [
SOCIATES	100' -		(SW) SAND: Fine to medium grain, heaving encountered
		100 MPS \$ 50/6"	(CL) CLAY: Silty, some fine grain sand, brown
SAC			Boring terminated at 105', 7-14-61.
SACRAHENTO	SUPPLIE	S/STRVICES - SURGIARY	Groundwater measured at 52' one hour after completion of drilling.
	Item Number	Quantity	107 feet of 4" Schedule 40 pvc pipe installed on 7-14-6
	0001AA	50 feet	Note: The stratification lines represent the approximat
E 2	0001AB	55 feet	boundary between soil types and the transition may be gradual.
DONING PAIN	0001AE 0001AF	4 6	
3 5	0001AI	107 feet	•
	000IV1	105 feet	
g l			
BORING LAG CLELLAN AIR FONCE BASE			
CE PASE			

BASE MONITORIUS WELL MWIS

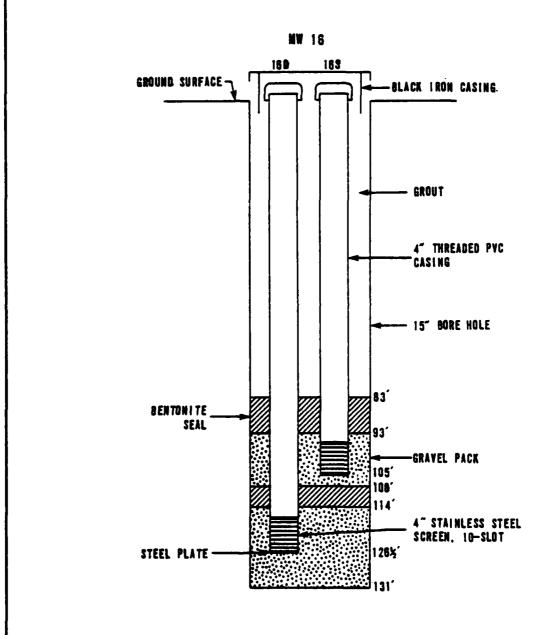
	Depth Q			(HZT.)		Some fine grain sand, can and brown
	20'	20 প্রহুর ি 45/6"		(SEL)	SILT:	Fine grain sandy, clayey, weakly comented, mottled brown, hard
		30 MPS [43/6"	L	(SM)	SAND:	Fine grain, silty, nottled brown, very dense
	40' —	40 MPS [50/5"		(MCL)	SILT:	Some fine grain sand, some clay, weakly camented, brown, hard
		50 HPS [33/6"	_	(52)	SAND:	Fine grain, relatively clean, gray with rust streaks, very dense
CORE	60' -	60 HPS [75	_	(167.)	SILT:	Very clayey, brown, hard
CHECKED BY		70 MPS [61	-	(CL)	CLAY:	Silty, gray and brown, hard
H. KLEINELIDIR & AS	80' -	80 MPS [40/5"		(SM)	SAMD:	Fine to medium grain, some silt, brown, very dense
PATE JULY 1981	100,	90 нря [46/3"		(ML)	SILT:	Some fine grain sand, some clay, brown, hard
SACRANEPTO PROJECT NO. A-1937-2		100 MPS [40/5" ES/SERVICES - SURMARY Quantity	L	Grow 7-28-	dvate: 81.	minered at 103', 7-28-81 r initially encountered at 78' during drillin f 4" Schedule 40 pvc pipe installed on 7-28-8
BORING LOG C CLELLAN AIR FORCE BASE C. A-1957-2 PLATE	0001AA 0001AB 0001AE 0001AF 0001AI	50 feet 53 feet 3 6 107 feet 105 feet		Note	bound	stratification lines represent the approximete lary between soil types and the transition be gradual.
CALIFORNIA						

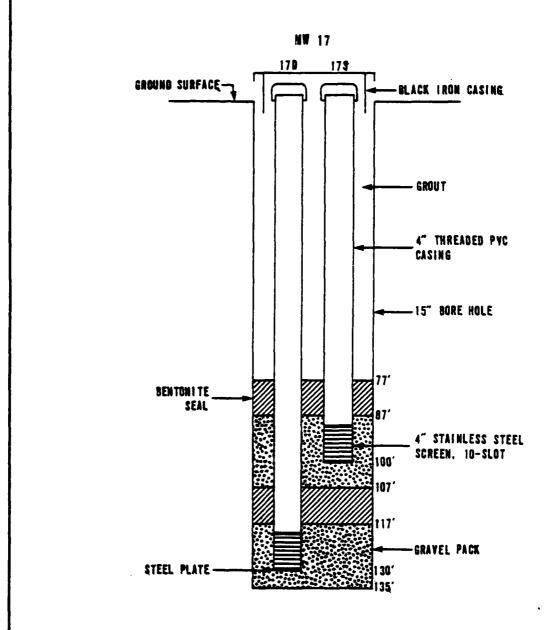
|-278

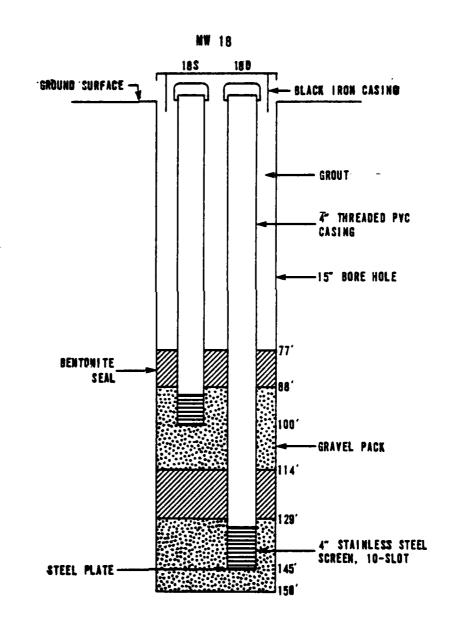
APPENDIX E

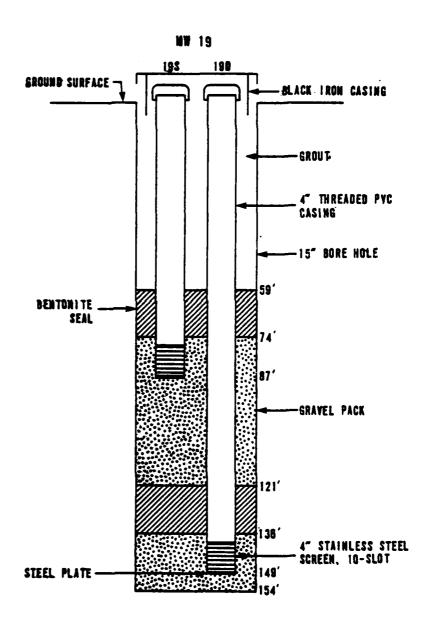
WELL DESIGNS AND WELL LOGS STAGE I AND STAGE II MONITORING WELLS

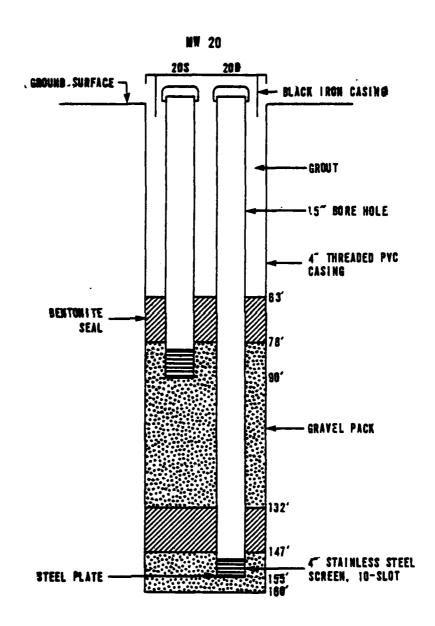
WELL DESIGNS STAGE I MONITORING WELLS

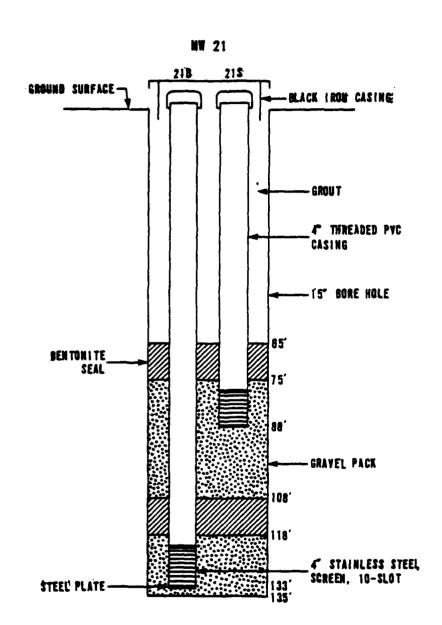




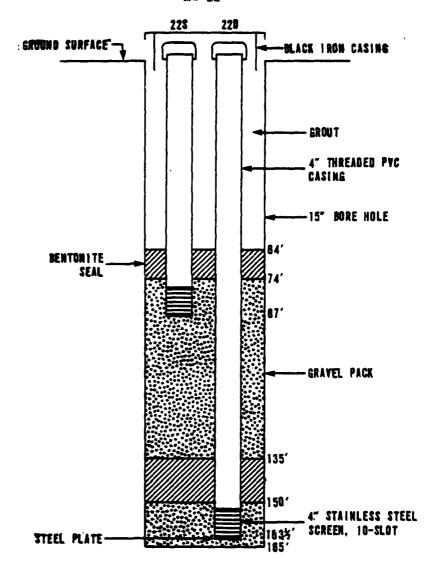


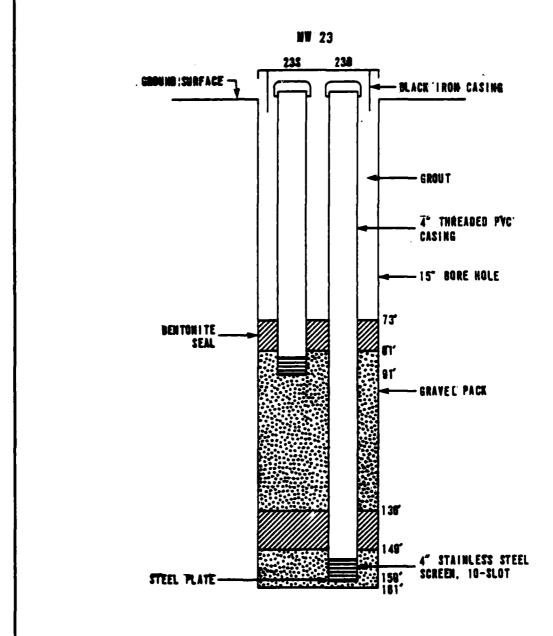






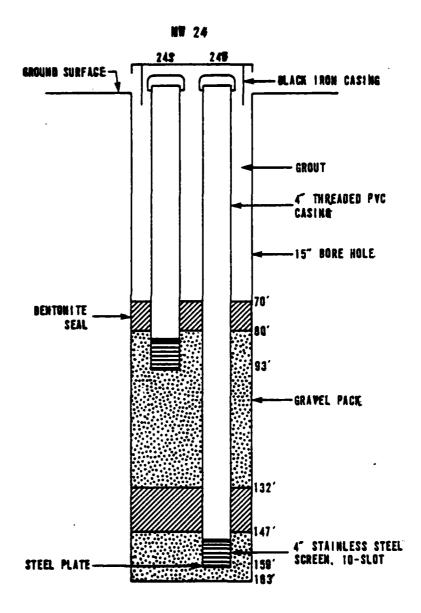


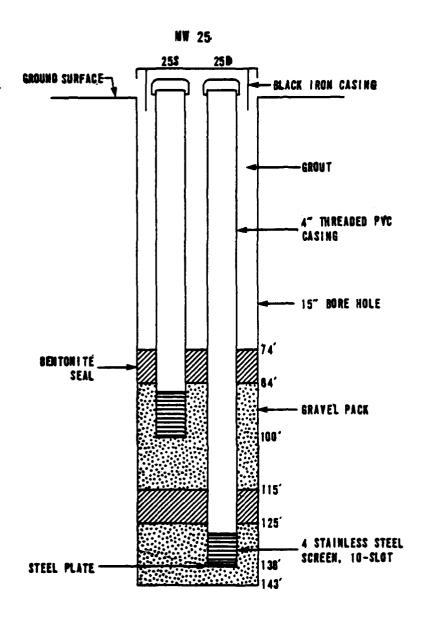


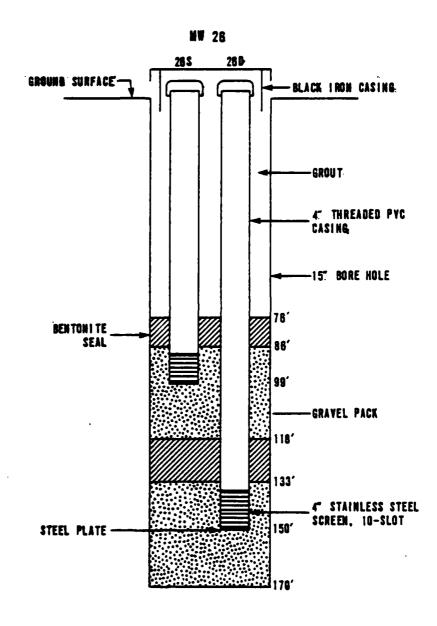


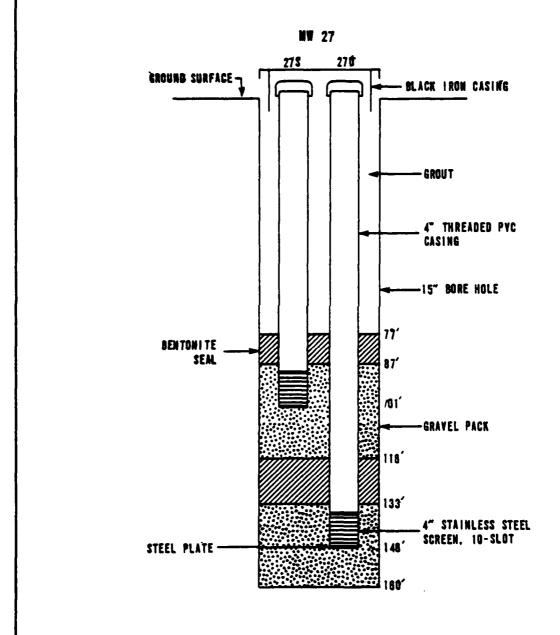
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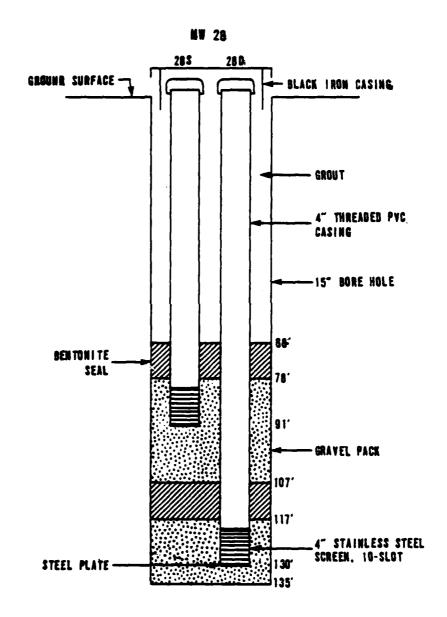
/-288

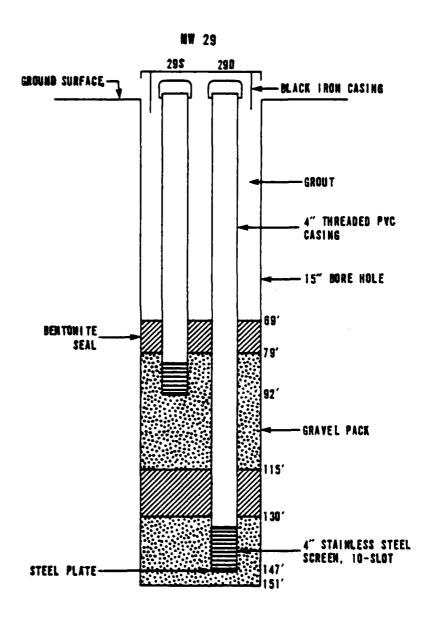






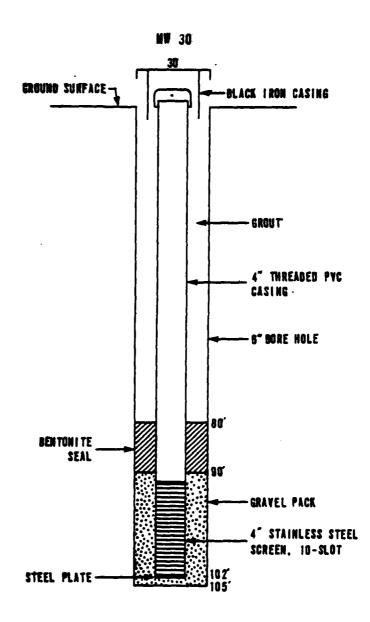


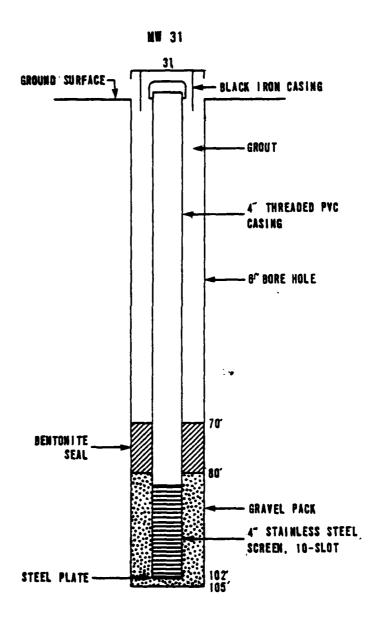




ENGINEERING-SCIENCE

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WELL LOGS STAGE I MONITORING WELLS



Well No. ES 16

Date: Uaech 10,1983

Location Mcaellan AfB, WORTH GATE

Altitude (Datum):

Method: Hollow-stem Auger

Size of hole: & " Size none, hole of casing pilothole

HT	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
2-		Cayovina. SC, 25° swars. ordu moist, plashe	n, SC	
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6		Hedrym Sand, Sw, John ran, w	"S	
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16				cemenaric suguray
18 -			_	
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22			- = =	wile clays, 1500 clay,
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44-			 } ∤	
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92 -			 	
54 -			-	
5% -		 	-	2001 - 10
75 -		sandy Clay, CL 1070 SUNG.	- kz	somphile

ENGINEERING-SCIENCE 600 BARCROFT WAY, BERKELEY, CALIFORNIA 94710 - 418/848-7970 OFFICES IN PRINCIPAL CITIES



ES 16

Date: March 10,1982

Altitude (Datum): Location by Clallon AFB

Size in the of e Size of hole: 811 Method: Hallaw - Stew auger

Drillow Stone Drilling & Explaintion, Rancho Couclova

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
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82 -			-{	
90 —			-{	
92 -			1	
94 -			d •	10% medium sand
0.8			Same 7	
100-	<u> </u>		Z	upt ourse Lin
102-			_	
10 Y			Cl	sand 1', augergoing fet
(06 =			1	•
100-			1	
112 -			I	
114 -	③		4	
116-	يو	citis and added	¥	-onage tip vot
118-		clotter	SM/SC	No.
120 —		1	hole cons	रिक्टा एट १२०

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	100

Well No.:

	733	Ditte		Date: pla
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		4 Wash		Size of casing
Driller: S	tara i	in the sections		15 (12/12)
DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
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Well No.:

Date: May 26 1922

Method: Rotary Wash

Altitude (Datum):

		i Wash Indina e Exclevation		of hole: 15 of casing 2 v				
EPTH		DESCRIPTION	GRAPHIC LOG	COMMENTS				
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Well No.:

Date: Hill III

Location			Altitude (Datum):			
Method:			Size of hole:	Size of casing		
Driller;						
DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS		
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Location:

DRILLING LOG

Well No.:

Altitude (Datum):

Method:		_	Size of hole:	Size of casing
Driller;				
DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
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The State of the S	
Location	MCC

	المراود والمتأثر			3-16-02
ocation	MCCI	relland	Altitude (
Method:	Hollor	J Auger	Size of hole:	8'1 Size of casing:
OriHer;	Stom	0/		
DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
2	4:00 34			
	┼	CL, very sitty, bu, ms, m.		
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23—	‡	CL, silty by some olive	millon	/
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	 	recipied for some	(SP)	by arey,
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Ham				40 FT. split spoon
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	 		-	CL 51 = 1,000.0
50-	 			SP, but in in firm
•	 			rd min
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				Besome 7:15 Am 3-17-82

ENGINEERING-SCIENCE 800 BANGROFT WAY, BERKELEY, CALIFORNIA 84710 - 415/545-7970 OFFICES IN PRINCIPAL CITIES

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Well No.: MW 18.

	Same of the same o			Date: 3-11-82
Location	Me	ckelland	Altitude (·
Method:		ow Auger	Size of hole: (of casing:
Driller;	STAL	16	T	,
DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
60				some wet cuttings 55.60 Ma
				perched water or from rain
	 	65 FT spt spoon		
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70-	 			29-55-70/6 inclus
•			 	21-34010 INELES
				Cl. V. s' Ha . Akha, iron Ms - s,
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	┼			80 81
•	 	 	 	17-25-\$ 16 inches
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?-88_		ce/es indive)		CL, sitty, dlb., s, vs
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94.	(.201.	TO 95 Ft		22-48-54/6 inches
95	13:35AM	1,095 +7	<u> </u>	· · · · · · · · · · · · · · · · · · ·
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		Water 89' 9:00	Km-3-	17-82
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The House Street	٦,	2 45	100	

Well No.:

Location	. 1	101	•		Altitude (Datum);	<u>'</u>	``_		ソン・	· - · <u> </u>	
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EPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
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Well No. MW19

Dete: 3-11-82

Location: McClellan AFB Attitude (Deturn):				
Method: Hollow Auger Size of hole: 8" Size of casing				
Driller: Stang Drilling				
DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
	MAOP:8	SP. brown-red Ln, loose,		
] -		sli. maist	-	
7-	 	SM, Hon-bn, md,	1	
10-		SM-MM	1	
12-				
' -		SP, ned. or. slidagey, 1	Ŧ	
-		bn-bn, md, sm-mm	1	
-~ .		 	1	auge/ Sample - 20 ft.
20 -]	*
]				
25-		CLISITY, Sli sdy, bu, MS-	4,	
]		SM-MM	4	
30, -			†	
32-		CL-SP interbedde &, bu,] .	
] -		ms, mm		
38	-	SPE + C1 = 11 1	b /	dila da M
40 -	 	SPFing + CL, silty, bn, -r.	gun.	split spoon 40 +t.
•		THE STATE OF THE PERSON AND THE PERS	1	
]	
48_			4	
50 -	-	CL, silty, ba-rdba, s-vs, r	mm.	
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	***			Well No.: MW 19	
		DRILLING L	OG	Dete: 3-11-82	
Location	MCC	Welland AFB	Altitude (Datum):	
Method: /	40/100	J Auger	Size of hole:	Size of casing:	
Driller:		e Drilling			
DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS	
60 -				60 ft-split spoon	
_					
70-					
•			•		
275 —		5P, medaro dk bu grey.			
		blkpont., md, wet.		77.5'-wat, bue alteredo	this a
80-	ļ	CI Millia d'anni C'lla		split spon - 20ff	
-		CL. dkbn, divegn, silta S-VS, moist-vely noist			
85	10:34 AM				
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Well No.:	\mathcal{J}

Date:

		<u> </u>	·	1 11 11 11 11 11 11		
Location:	1-1000	ellon	Altitude (Datum):			
Method:	204071	リリンニア	Size of hole:	Size of casing		
Driller:	シックス	Er 12 & EVP DY	うだりい	10 1081 10		
DEPTH	i	DESCRIPTION	GRAPHIC LOG	COMMENTS		
		on still clay	166			
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A CONTRACTOR	A TOWN			Date: 3-11-82
Location	McC	Ielland	Altitude (Datum): —
Method:	Hollor	w Auger	Size of hole:	Size of casing:
Driller; <	STAN	6		
DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
7		Toposoil		
		SP, clayey, medart		
-		Figr. bu-red 1-md	י	· · · · · · · · · · · · · · · · · · ·
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/0-				
17-		SP, medge, some dk.		70 St. 2000 50 male
20		1-md, mm		20ft-augs sample
23		CL. Sithy, blk arasules		
26-		bn-arn ins-s sm Spinedar-CL silty		
≫ —		interbedas, rabn-bn		
33-		SP, F. to medar, bu, nd	4M.	
22		+ Chysitty, from staining	i riev.	
		by, vs, sm introbals		
40				40 ftsplit span
42-		SM CILL In I can	}	· · · · · · · · · · · · · · · · · · ·
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어-		the gray.		<u> </u>
}		CL, sitty, rd bu, ns, sm-mr		· · · · · · · · · · · · · · · · · · ·
				

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	est white with	Prince of				3-11-0	3 < _
1	Location	MC	Clelland	Altitude	(Datum):		
	Method:	401	low Auger	Size of hole:	8"	Size of casing	
	Oriller;	STA	NG				
	DEPTH	TIME	DESCRIPTION	GRAPHK LOG	<u></u>	COMMENT	rs
	60						
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	72-	•	CL, sli sith dbn, ms-s	m			
	76-		'''				
			SP-CL, bn-qy bn, ironsta	كفا	 		
	80 -		SP-CL, bn-qy bn, ironsta + SP, fig, bn-ey bn intented's, nd-d, nn	j	spli+	5,00M1 - R	oft.
2	-84 -		SP, medige, bn-gray bn, n	į .		spom - Ri Raporex i	02.51
	87-		- CL auto Liveby Sli	A,WCI.	WATE	Raporex	87 17 .
	90 —		- CL, quito diveba, sli silty, h, mm]			
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ENGINEERING-SCIENCE 600 BARCROFT WAY, BERKELEY, CALIFORNIA \$4718 - 418/848-7970 OFFICES IN PRINCIPAL CITIES



Well No.: 20

		DIVILLING	- -	Date: 1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/1/
ocation:	McCh	ollan		(Datum): (20)
dethod:	2cias	y プランジャー	Size of hole:	Size of casing
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DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
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ENGINEERING-SCIENCE

800 BANCROFT WAY, BERKELEY, CALIFORNIA 94710 • 415/548-7970 OFFICES IN PRINCIPAL CITIES

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WOR NO.: MW 21

Deter 3-11412-82

Location	MCC	Ielland AFB	Altitude (Detum):	
Method:) Avor	Size of hole:	Size of casing:	
Driller;	Stan-				
DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS	
1-	Z:50PM	Topsoil dk bn CL, silty, dk bn, ns, mm	(1		
7-		CL silty bu-iden ns n	101		
10 -		am bu, vs, sm			
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-				and same and a	
Z0 —				ouger sample - 20 A	
25.		SP, u silty, bu, nd, wot	<u> </u>	3:30 PM STOP at 25+	r ;
28-		SP, F.gr. bn, md, mm	SP	I ft thick perchad w	<u>a+2~2</u> 5-2
-			-		
38-	<u> </u>				
40 -		CLISIHY, MLIBA, MS, SY			
-		ML, clayer, Figr son, iron staining, md, sm-r	ML -	45ft-splitsocon	Somp
50 —				,	
		SP-CL interbeds		•	
59-					
603—		CLIV silty rd by VS, MM	<l< td=""><td>60 st - solit sommer</td><td></td></l<>	60 st - solit sommer	

ENGINEERING-SCIENCE 600 BARCROFT WAY, BERKELEY, CALIFORNIA 84710 - 418/648-7970 OFFICES IN PRINCIPAL CITIES

	5	DRILLING L	og	Well No.: 19W21 Date: 3-11-12-82
Location	سردر'	Ichland AFB	Altitude (
Method:	Hollon) Auger	Size of hole :	O II Size of casing
Driller;	Stana			
DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
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70 -				
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≈13 —	•	SP, Fig., wet	-SP3	
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<i>∞</i> –		CL, sli silty, bu-gry be vs. vm, iron stamina	,,,,,,	80ft - solit soon
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Well	No.:	. '	

Location: NAC / Services			Altitude (Datum):		
		1 1/1/10	Size Size of casing C		
Oriller; 📑	49500	in 100 1 1 1 1 1 2 1 2 1 2 1 2 1 2 1 2 1 2	.,	16.2	
EPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS	
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ENGINEERING-SCIENCE

800 BANCROFT WAY, BERKELEY, CALIFORNIA 947:0 - 415/548-797U OFFICES IN PRINCIPAL CITIES



Well No.: 5522

Date: 3/13 /82

Location: HCCICIAN AFB, Sacramento Altitude (Datum):

Method: Hollow-stein auger size of hole: 8" Size Nove of casing pilet below

Driver: Stava Drilling & Exploration

GRAPHIC

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
۷.	10:00	ciairly sand, CL, 10% fines, wedlish brown paist destrictive	٥	some cementa 700
4.				
6-	L		7	ivon claims economided elem
8-			7	/
10		1	7	dayle tan
•			7	
12 - 14-	•	Log ton line must	SM	
16-				•
18-	6		7	composed classificar
20-	2		SC	
24 -		copy sank, ct, 1000 fines, agrillsh brown, meist, plostic kines		cementation by entry to the in
•		hard	7	
26-			1	brown, won concerted
28-			1	
30			1	
32-			1	
34 -			•	
36 - 38 -			†	
	In 10 F			consented clay layers
49-	10.0	medicing soud, SW, >5% hous,	3W	enthile ainte
42-			1 "	
44 -			7	
46 - 48 -			1	
-			1	· · · · · · · · · · · · · · · · · · ·
50-			†	
52 - 54 -			7	
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ENGINEERING-SCIENCE *** BARCROFT WAY, BETWELEY, CALIFORNIA SETTING-11 TOPO OFFICES IN PRINCIPAL CITIES



Well No.: ES 22

Date: 3/13/82

Altitude (Datum): Location Mc(1010 AFB, Sacrowento Size of hole: 8" Size of casing none polo Method: Hollow-stem auger Driller. Starg Dulling & Exploration Raucho Covdora GRAPHIC **COMMENTS** DEPTH TIME **DESCRIPTION** LOG eon clay CL brown low iron stains 62 plasticity. 64 66 70-72 74 76 72 80 clavich brown hard 82 14 V wet anier clower silt som brains 12:00 Low planticity, havd trave co-valeted 32 851. 90 -٩Z 94 98 105-

ENGINEERING-SCIENCE 600 BARCROFT WAY, BETWELFY, CALIFORNIA 64710 • 416/540-7970 OFFICES IN PRINCIPAL CITIES

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Well No.:

Location: }.	·11:21104	Altitude (Datu	
	lawy Wash	Size of hole: 15	Size of casing 2
Driller: \mathcal{S}^{γ}	alla Dal das ??	2100 15000	
DEPTH T	IME DESCRIPTION	GRAPHIC LOG	COMMENTS
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E	arean sandy con		
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7-7-6	inclayer soud		
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Well No.: MWZ3

Date: 3-12-82

Location	MC	Clelland	Altitude (Datum):
Method:		low Auger	Size of hole:	Size of casing:
Driller;	Stan			•
DEPTH	TIME.	DESCRIPTION	GRAPHIC LOG	COMMENTS
/-	MA 04: P			
4-		SP, clayer rd by nd, m	<u> </u>	
'-	<u> </u>	CL, say, rd by, ns, nm,	<u>. </u>	
a -		100 staining		
10		SP, sh clayey, bu, nd, s	<u> </u>	
	•			
18-				
20 -		CL, sli say, broakb	1,MS	00.61
-		SM-MM, iron staining	1	20 ft- auger sample
-				
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30				
30 —				
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40 -				Un A colit come
				40 A-split spoon
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Well No.: MW23

Dete: 3-12-82

Location	MC	Clelland	Altitude	(Datum):	٦
Method:	401	low Auger	Size of hole:	811 Size of casing:	
Driller;	Sta	19			
DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS	
6					
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70 -					
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80 —				80ft solit soon	_
285 ·					
~ -		SP, clayen (sli) by, figr.			4
9-		PRI-A, WET		 	-
90 — 92				90 ft split spoon	٦
		CLIVS-s, hand & (no a	uga son	me)	
95 —	1:00PM	T.D.95 ft.	ļ <u> </u>	<u> </u>	_
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ENGINEERING-SCIENCE

GPD BANCROFT WAY, BERKELEY, CALIFORNIA 84710 • 416/849-7970 OFFICES IN PRINCIPAL CITIES

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Well No.: 23

May 23 2 2 Date:

Location:	McC10	$\mathcal{L}(h)$	Altitude (Datum): جات يان المان الم			
Method: Commence of the State		Size of hole:	5" Size of casing -			
Driller: 💲	وروادي	ly has estim	כש תוורים	11.60 (01/1/11)		
DEPTH	1	DESCRIPTION	GRAPHIC LOG	COMMENTS		
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Well No.: MW24

Date: 3-12-82

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Location	Mec	Ielland	Altitude (
Method:	Hollon	w Auger	Size of hole:	Size of casing:
Driller;		ng'		
DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
2.	1:1384	Fill ocupt scories	દ	
4 -		3P, sittly along blass	5'WW-W	
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12-	-	of bu-bu, ind m		
14-		CLisitty by andi		
		S, M and râbn -iron		
20-		Spining		
				20ft auger sample
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30 —		<u> </u>		
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140-	ļ	Clisity rdbn iron	ļ	40 ft saitspread
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		bu. 5-US, MM	 	
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DRILLING LOG

HSMM : ON HOM

Date: 3-12-82

Location	Me	clelland	Altitude (Datum):
Method:		in Auger	Size of hole:	Size of casing:
Driller,	Hay	na Drillina		
DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
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70 -				
274		SP. F.gr., sitty, bu	 	
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80-				
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94-	3:30PM	-cl, sitys-us -mm T.O. 951		<u> </u>
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U Well No.:

Location:		TOV	Altitude (Da	tum): 58 2 12-52
		Wrsh	Size of hole:	Size of casing -
Oriller; 💲	47.26	Drilling & Explos		
DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
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ENGINEERING-SCIENCE 800 BANCROFT WAY, BERKELEY, CALIFORNIA 94710 - 415/548-7970 OFFICES IN PRINCIPAL CITIES

Well No. ES 25

Date: 3/15/62

Location: MCChellou AFB, Sacrawtufo Attitude (Datum):

7,

Method: Hollow stem outen Hobile 8-53 Size of hole: 8" Size name prot hole

Driller: Stong Dulling Exploration. Rancho Cordova, CA

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
۷ -	10:00	Sordy clay 20% Soud, cl,	CL	
٧.		, and the second] .	
6		Well anded cand Surleant	sw -	
8.		by c successfines, moist,		
10 -			ļ	
12 -		<u> </u>		
14-			ļ <u>.</u> ;	
K -		<u> </u>		cemenical clay w/ from stains line sand
ાઢ -		Clavey sand . St. 25% Lines.	RC	
20 -	<u> 3</u>	Clayer sand, 36, 25% knes,		irea-showed converted on
22 -		we graded with the said su, not se for 10000 man range	SU	
24 -		rengish on loace mak-proche	1	
26-		claused sound SC 28% clay		
28 -		arbun /	sc.	~ ≠.
30-			د حسود	prohid vatir
32 - 34 -		well graded medium sand, sw, meldich by lonce have plactic	sw :	iron-stained boards
36				
38 -		·	10 ⁻⁴ . 44	
40	<u>G</u>	•	•	nint
42 -	9			
44 -				
46 -		<u> </u>		
48-				
್		any y soud, sc, 20% sout.	5	
52 -		Section 19 May	SC E	perdish war, uet
54 -				
56 -				
58-		sauch silt, 10% sour light		
40-	3	the lackd win place	H	

ENGINEERING-SCIENCE

600 BARCROFT WAY, BERKELEY, CALIFORNIA 94710 + 415/548-7976 OFFICES IN PRINCIPAL CITIES



E525 Well No.:

Date: 3/15/82

Location: McClellou AFB, sorrougute, LA

Altitude (Datum):

Method: Hollow-stern augar, Mobile B-53

Size of hole: 811 Size of casing: policy hale

Driller;

EPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
62 -			hr)	
14 -				
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62-			1	
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5	12:4511	T.D. 105'		
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Well No.: 25

Date: Transport 129 3

Method: Rolling 1999			Altitude (Datum):			
Method:	2010/	1 1177-1	Size Size of hole: of casing			
Oriller:						
DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS		
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DRILLIÑG LOG

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WOR NO.: MW 26

Location Altitude (Datum): Size of hole: Size of casing: Method: Dritter: GRAPHIC LOG DEPTH DESCRIPTION **COMMENTS** TIME :20 PM ta above claver by md, rim 20 20 FT. AUGER SAMPLE bu-oction staining, MS-5, MM 40 50

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				Well No.: MW 26
		DRILLING L	.OG	Date: 3-17-8Z
Location	Mc	Clelland	Attitude (Datum):
Method:	Holle	on knock	Size of hole:	Size of casing:
Driller;	Stan	7)		
DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
61-		cl sity, MS, SM-MM		60 FT SPLIT SPOOL
			ļ	18.22-26 /6 inches
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-				
70-				stough CL, sitty, MS, SM-ym
· -				
_				
20 -				0
, -		<u> </u>	<u> </u>	80 FT SPLIT SPOON
-				80 8
-			 	134-62-74/6 inches
C-			 	(775)
90-				CL, sli silty, bn, s-vs, r
71	7			STOP AT 3:00 PM- at 90'-RAVI
`` -		sp, wet		START 8:40-3-18-62
			ļ	out at 298 during drilling
100=		cl, ba-dive ba, sli silfu, us, na-m	ļ <u> </u>	
-	-	אוווירי ביוואריי		100 C/ 100 love do 51 Hz
105!-	9:20AM	TO	 	CL, ofice buildisilty
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		1		*** · · · · · · · · · · · · · · · · · ·
		Nater - 41 of 10:00	Mater	pulling auger -
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Well No.: 🗀 👉

Date: 11 2 / 2 / 2

Location:	cation: Pic (12/1014		Altitude (Datum):			
Method:	cotass	1 Wash	Size of hole: 15 Size of casing — 12			
Driller: S	tare.	[1 1111/16 5 -11				
DEPTH		DESCRIPTION	GRAPHIC LOG	COMMENTS		
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/-330



ES 27

Date: 3/13/82

Altitude (Datum): Location McClellan AFB, Sacrawento

Size MONE of casing p. 10+ 10010 Size of hole: 8" Method: Hollani-stone auger

EPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
2 =	12:55	Fill, concrete blocks	FII	
4 -		closes and SC 20% fines	SC	
6 -		wash brown, moist, low	_	
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ю 		and the day a baut on	CL	
12 =		-20% gatel and coarse sand		
75 -		Madish on, moist, low post-	<u>د</u>	
16		radish on, moist, low plasm-	1	iron-stein dan consuted
18				
20-	ſ.			30% Eves
<u>ک</u> ر ۔	۵_]	
24				
26		sendy clay town maist law	CL	computed iron stains
25		prostring, 20% fine sound		
		,		
32 32 -		Cloner cand 1505 kins	56	
34		Mddith by, moist, low		
ء م چ				
32 -		Soudy day (1 40% sound	u	renite
	ב	on, moist, low particity]	
42	₩	U (11 Graded midum sand, sour 1000	S _M	lion stoins
44		classon same se 1501, him	Sc	
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ENGINEERING-SCIENCE 400 BARCROFT WAY, BERKELEY, CALIFORNIA 84710 - 416/846-7970 OFFICES IN PRINCIPAL CITIES



Well No: ES 27

Deter 3/15-/82

Location Mcliplian AFB, Sorrowen to

Altitude (Detum):

Method: 15110w-skin augar Mabile B-33 of hole: &" Size none pilot hole

Driller: Stang Drilling & Exploration, Roucko Cordova

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
62 -	שיך		Σ	-perclud weter
4 4				
66-		<i>.</i>		zueze deg
હ્યું -				
72 -	,			
72]	•			
76		1		
7,4			1	
	17/10		1 _	
85		write-aded in edition	su	
82 -		sand sie, light ordinish		encited
٤4 -		- 42	CL	
\$¥ -		Sanay Clay, CL, greenish	1	7
5℃		,	1	
70				
92 -			†	
?7 =	R)	write and of madellin cond.	Z UT	inst ourse minte 95"
96 -		sw. thrownsh black, louis,		The second second
45° =	9:30		CL	
100 		 	hole cours	
			ינטי	
٦		.,	1 ~	
. 1				
1			j 1	
7	-		1	•
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1			1	
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		 	† 1	

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	\bigcirc	DRILLIN
Location	VI/	1-11021
Method:	entory	Wash
		Disting 85%
DEPTH	TIME	DESCRIPTION
20 /		greenish med sold
-		
-		

120

20

150.

		Mell NO"		/
	100		<u> </u>	-
LING	LOG	Date:		

Date: 1/7: 1/ 2/3/2/2

1-1021	Altitude (Datum): 71.8 ルバ
Wash		Size of casing
Disting 85, por	y > 1 (7
DESCRIPTION	GRAPHIC LOG	COMMENTS
enecticals med solve clay	CL	
	4 ;	
	-	
	†	
	1	
] .	
clauses sand, bn, areensh		
21000000	ا کک	· · · · · · · · · · · · · · · · · · ·
accorded clayey silt		
Che C Street Code 4 Street	174	
	 	
	T.A. 160	

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\mathbb{G}^-		7		
3		4	4	- ₹
	يسن	-6		• H
텔_				

Well No.: MW 28

Date: 3-18-82

Location	MC	Clelland	Altitude	(Datum): ·
Method:		ow Auger	Size of hole:	811 Size of casing:
Dritter;	Sta			
DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
2-	10:20	Topsoil CLV. sitty bu some		
-		I'm staining & SM		
		71 7 314		
10-				
12-			ļ	
	•	CL, sdy by iron staines		
17		3, 300 - 1111		
20		9. sh clayer bn. rab		
1 4		d, sm	/	20 FT LUGER SAILIPLE
4				S/figs, si dayen, bn-
-				rasi, d, sm
30-				
-				
38-		ch bu = silty, s. mm		
φ-		ion staining occ.		40 FT. SPUT SPOON
-		organie.		
مرر ا		\\		12 - 21 +34 / 6 inches
18- 50-		SP, far, by, slisitly,		12-21/34/6 incres
30		sec cl interbedding.		CL, bu-silty s, mm
-	<u>.</u>	md, mm,	-	
-	•			<u> </u>
				

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				WOR NO.: MW 28	
		DRILLING L	OG	Well No.: MW 28 Date: 3-18-82	
Location		Chelland	Altitude (Datum): '	
Method:	He		Size of hole:	of casing:	
Driller,	<u>S</u> F	ang			
DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS	
80				16-26-31 /6"	
-				60 FT SPLIT SPOON	
-				6	
70-				St. f. ar. bin somering	
,				stancino md. d. SM	
-				-	
				,	
20		•			
7 -		1 1 0 1		80 FT SPLIT 5POON	
`		SP, saturated - top wkn	₽₩ ^	80 81	
48 <u> </u>				33-76-70/6"	
_		=L, bolive la, vs, m,		Chushy, bn	5,19
90		si silty		· · · ·	,
-					
-					
100					
_	11:50M	T.D.100 ft		100 FT. SPLIT SPOON	
_				/20 /01	-
				LCLibr-divela, us, m	
		`		tipe samples, wet	
-				15-76-39/6"	

1

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7-33\$

				Well No.: MW 29	ł
		DRILLING	LOG	Date: 3-16-82	
Location	Me	chelland.	Altitude (Date	um):	
Method:	teller	W Auges	Size of hole:	Size of casing:	
Driller:	Stan	^4			
DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS	
17	1/250AM	- Artificial fill, grave			\Box
_3 _		- SP, gravel, dh Sn,			
-	 	CL, sitty, occ. 1100	staining, an	, M3, 3M	
•			 	· · · · · · · · · · · · · · · · · · ·	┥
10-				· · · · · · · · · · · · · · · · · · ·	
	•				
16-					12:
10		SP, sli clayer, by, -ce, shistin, x: : du,	md, sn-mm	<u> </u>	RA
20		- a, susity, 31: : du,	m-orecom M		}
4				of FT Argen Sangle:	
25-		Shiclayey mostly a	lean by gol.	sm-mm, like above sand	7
				layer.	
30				V	
ر پر		<u> </u>			_
_					_
37—		CLIVSIlty, bu-delen	- F - 1 - 1 - 1 - 1	ion stamuis &	
•		some (d.	~; 3203, 7104, 7/	ron stamuro	\dashv
4૭—			9	OFT Split spoon	
		ac shintelals.	2	3-45-66/6 inches)	
•			- 4	41	_
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4			<i>' J</i>
	5	 	4) 4)

Well No.: 28

Date: 1978 3. 1982

Location	Miche	110%		Datum): 72. 6 2156
Method: 8	0+021	YJUSh		5" Size of casing 2 " 1
Driller:	Sova	Duillina : E flor		Rainly work w
DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
100		greculate on sity closy	CL	
-				
.20 -		Pyntic	SP	
120 -			-	
130			T. D. 130	
140-				
-				
-				
-				
-				
-				
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and the	2 4 3 E 4
Contract of the Contract of th	
Location	MCC

Service P	10000			Pate: 3-16-82
Location		lelland		(Datum): '
Method:	140/	low Auger	Size of hole:	Size of casing: /
Driller:		stang '		
DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
٠				
-				
-			 	
_				
70 —				
	•			
-				Siller didn't kvan where
				Soul in 80' sample nos
80-		•	ļ	encountered.
•		h a a a a	ļ	21-33-43/6"
4		to A sample at 801		21
4		WEI .		SPIFIAR, DAISH dancy:
20				nd-d, mm
				23/52/51
				90 91
95-	2:26	T.D 95		LCL, sli city, direace
-				S-VS.
				sample wet at 90st
	 			
-		unter after \$-81' 7:	45AM 3-	17-82
, -		7 //	12/4/ 3	1/ 32
-				
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-				

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Well No.: 29

Date: 10/01/26 192

				POK N 20 0 5
Location: MCC/EIION			Altitude (
		111950	Size of hole:	
Oriller:	staua	Dulling & Explo:		
DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
25/-		Olive state and reactism	CL	
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05 —			1 1	
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25-			-	
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		bn silly arovel	GMD_	
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基本专案				Well No.: MW 30	
		DRILLING L	.OG	Date: 3-17-82	
Location	Mc	Clelland	Altitude (Datum): 73.0 WSL	
Method:	Ho	1/ew Luger	Size of hole:	Size of casing:	
Driller.	Sta	ne Drilling			
DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS	
/	10:0044	الكرادودو الكرادودو ا			
4-		CL, 1 shy rd sn. s,1	4		
'-		KL, s. Hy, say by rows	pining,	Ms, MM	
109-		SP, v. figr., Hbn-bn, m	sm (s	i dayey)	
12-	•	Cl v ailt his me			
-		CL, v. silty, bu, ns,:	3 /1		
•					
20-				20 FT auger sample	
24_		759		CL, sitty iron staining, bu, ms	S 1 ² f- 14
		ML, clayed, bu, md, n	m	. / /	•
28-		Sp. v.f.gr. Hhn-bn.	54 6.40		
30-		sech sel interes	77 77		
_		7		SWAH CL SP	
				71/11-1-1	
_				40 41	
40_			<u> </u>	40 FT, SPLIT, SPUCIL	
-				(6-31-4016"	
46		gon stauring		and Clisitic alu Missi	A
76-		CL, v. silty, 5-vs, sn. vm	(0000 mers la s	iron staining in CLT SP.	** 11**
<u></u>			water)		
50 -	,				
51-			ļ		-
' -		SPbn-grey, nd-d, sn-M	M	60 f? SPLIT SPOON	 :=1
,			 	المراب ال	~ `
1 <i>6</i> 2			1	6/	

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				Well No.: 19W 30
		DRILLING L	OG	. Date: 3-17-82
Location	Mcc	telland	Altitude (Datum);
Method:	Holl	on Aige	Size of hole:	Size of casing:
Driller;	She	ano_		
DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
•		occ CL interbeds		
-				
-	 			
70				
-				
78-				
20-		CL, very sifty, bn, vs,	m	RO ET. SPLIT SPOON
82-		SP. Sn. d. M & wet		80 381
_				CL, v. sitty, bu, vs, mm
87		-c. bn-dnebn, vs, m		15-30-32/6 inches
·87		53-51-51		IIP ALL TO KIG
-	<u> </u>	7		
•				
/ <i>∞</i>	10.15	T.D 100 ft.		
_	12:15	Noterlevel after do	alling +	- coved to 93ft. NOFT samplefrom acque
•				CL, slisity, director us long
				/
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				and the second s
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	بريب	

30 Well No.:

				Date: Hay 27 782	
Location: M([/ellon			Altitude (Datum):		
Method:	of av	1 Wash	Size of hole:	(Size 4 !! of casing	
Driller:	s: nua	Living & Explor	ation.	Raucho Grillia	
DEPTH		DESCRIPTION	GRAPHIC LOG	COMMENTS	
		Dods 1/ad 2404	}	 	
-		hole to install	†		
-		PVC			
-		PVC	† .		
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600 BANCROFT WAY, BERKELEY, CALIFORNIA 94710 • 415/548-7870
OFFICES IN PRINCIPAL CITIES
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31 Well No.:

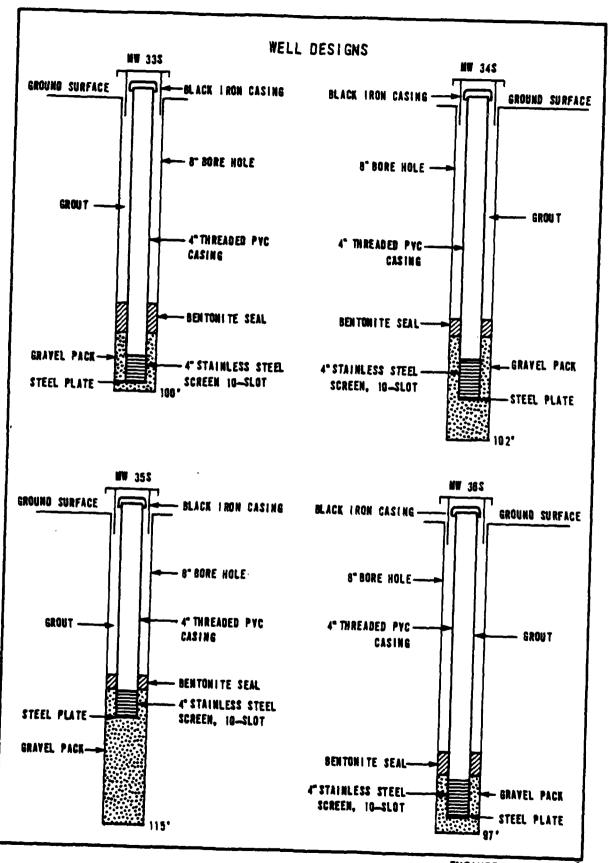
		DRILLING L	.OG	Date: 12011 28:10 82
Location	Mil	lellax		(Datum): 65 8 Will
		y 11/05h	Size of hole:	Size of casing
Driller: 5	taus	Dulling & Explo	ration	ROMAN ONLY
DEPTH	, ,	DESCRIPTION	GRAPHIC LOG	COMMENTS
		ion. siry cicipey saud	SM/SC	
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		on area in cloudy is +	ML	
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ر د				
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		be are claim si-	ML	
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4		ion greenish silty clay	ICL	
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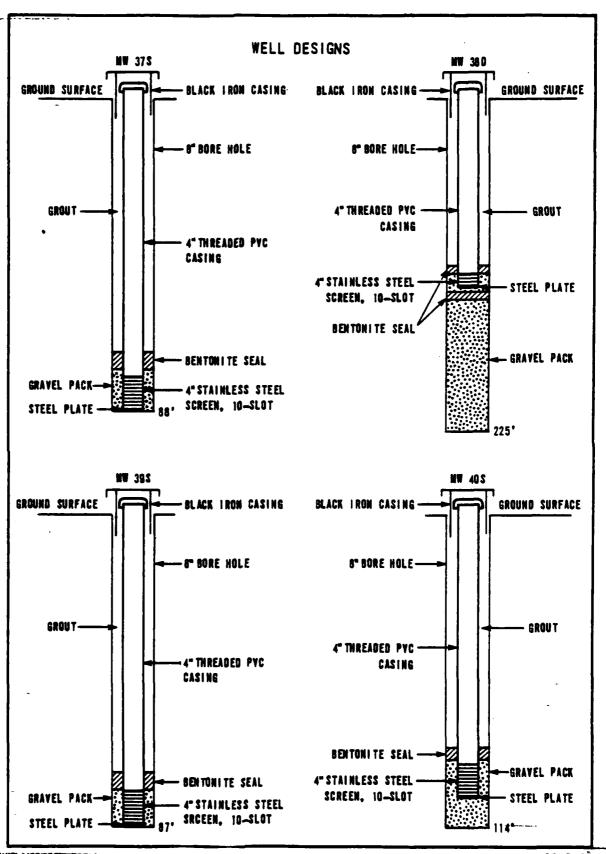
600 BANCROFT WAY, BERKELEY, CALIFORNIA 94710 • 415/548-7970 OFFICES IN PRINCIPAL CITIES

WELL DESIGNS

STAGE II MONITORING WELLS

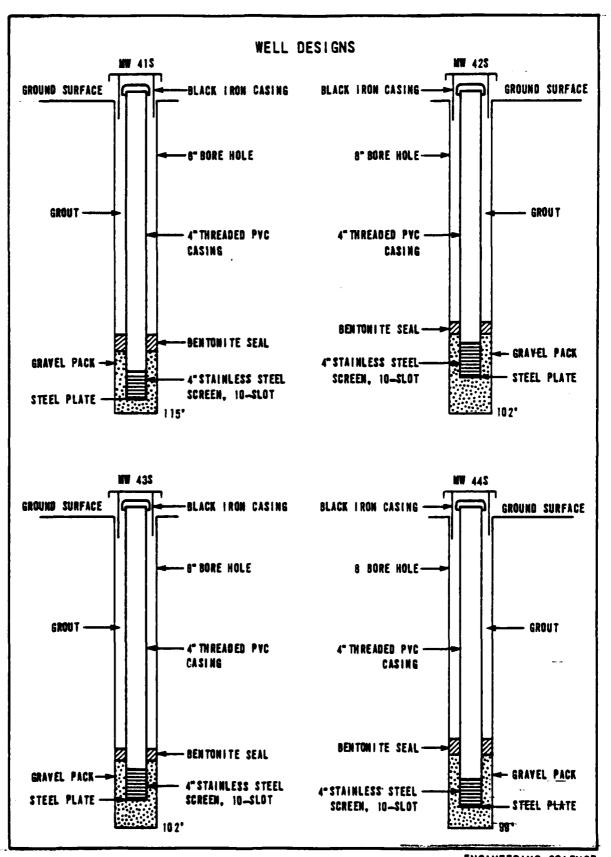


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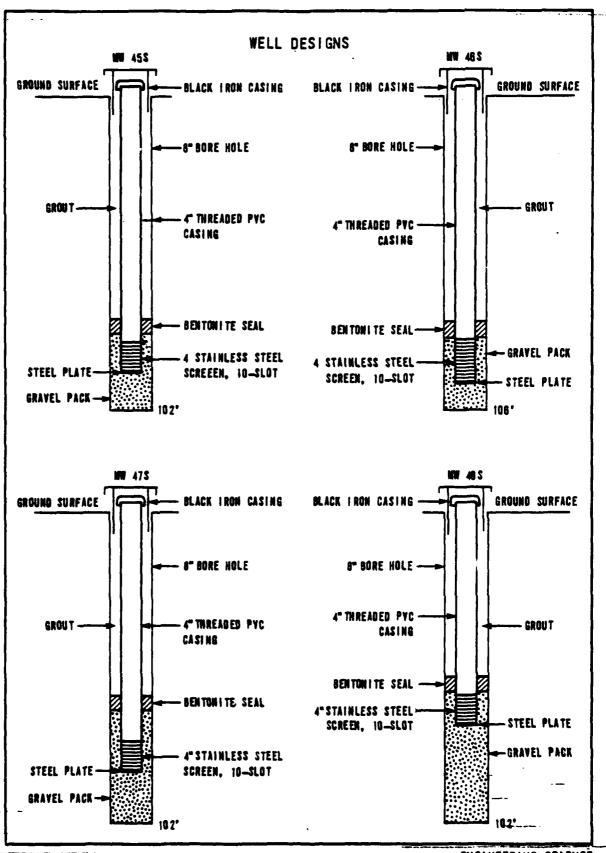


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ENGINEERING-SCIENCE 1-347



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WELL LOGS STAGE II MONITORING WELLS

WELL	335	

1	WELL CONSTR					,
]	LOCATION or COORDS:	ELEVATION: GROUP	ND LEVE	L <u>5</u>	8.28	<u>3' </u>
}		TOP O	F CASIN	G		
- 1	DRILLING SUMMARY:	CONSTRUCTION	TIME	LOG:		
1	TOTAL DEPTH 110		<u> 51</u>	ART	FIN	ISH
	BOREHOLE DIAMETER 8"	TASK	DATE	TIME	DATE	TIME
1	DRILLER Water Development	DRILLING:	91,-	1645	9/17	1752
F	Corp. Woodland, CA				_ ```	11
1						
	RIG ROTAM - Drilltech DYCK BITISI Italia	GEOPHYS. LOGGING:				
L	1	CASING:	9117	1800		2000
	DRILLING FLUID Natural					
.	SURFACE CASING	FILTER PLACEMENT				
		CEMENTING:				
-	WELL DESIGN:	DEVELOPMENT:	अनु।		1/21	
	BASIS: GEOLOGIC LOG X GEOPHYSICAL LOG CASING STRINGIS: C+CASING S+SCREEN	OTHER:				
1 1	- 87 CI					
•	87 - 97 5					
FILL				_		
ML		WELL DEVELOR	MENT	<u>'</u>		
1						
-26						
	CASING: CI 4" PVC SC4 40, thea- c2 ded					
SH	3					
CL	SCREEN: SI UI Stainless steel, 10 slot					
40	SCREEN: SI STATE STORY STORY STORY					
SM	\$3	COMMENTS:				
CL	54		 			
HL	CENTRALIZERS					
م	112-12-21-22					
	FILTER MATERIAL MCH GULU Sand #3	 -				
	CEMENT Grout 70'- gr. wel					
-80 <u>SH</u>	OTHER BULLONIE SEAL 80'-70'					
Pravet pack						
, v c c						
-100-						لــــــــــــــــــــــــــــــــــــــ

LOCATION MCLELLAL AFB, CA PERSONNEL YAVE NOVOLHAV, ES

PROJECT MC (PORM IRP Phuse II



Location McClellan AFB, CA Altitude (Datum):

Method: Potavu rugela - ruina oi - el hole: 8"

Driller: Water Devotopment CAPORATION Vocality

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
3-		F: II	Fill	•
-		Claver sanduítico 5%) silt, rd	HL	
15		Clave, [5%) silt		
-				iron stails
30 —		Silly Give sand ad	SM	
		Silty (10%) sandu	CL	
45-		Fire sand red	s H	n. 12 2240
		Sandy clay redion	CL -	
6C		Silt It om	M_	mica vans
-				
75 -				streaks of the day
-				
		Sand, merling-fine bladz-white	SM	na (Caseaus
<i>ii</i> —		Clay arecush-krn	CL	

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8_			
	أيسان بالسائيم	Tarren in	*

Well No.: 335

(con-nuced)

Date:

ocation:			Altitude (Datu	m):
Method:			Size of hole:	Size of casing
Orlifer,				
DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
•			CL	
•				
•			T.D. 100'	
105-			 	
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WELL 345

		[7	W	IELL TY	<u> </u>
• • • •	·	0 CL MD-00 5D CL	WELL CONSTR	ELEVATION: GROU	ND LEVEL5	8.17
		Cc	MCCCELONG HTS	TOP (F CASING	<i></i>
	1 .	-/6	2011 1110 0111111111111	201107101		
	11	50000	DRILLING SUMMARY:	CONSTRUCTION	_	1
	11	<u> </u>	TOTAL DEPTH 102	TASK	START	FINISH
*		PHIPH	BOREHOLE DIAMETER		DATE TIME	DATE TIME
	18	CLOSD \	DRILLER WIR. DEVEL. COLP.	DRILLING:	8/30 11:15	3/31 9:10
	4550	-20 CZ.	DRILLER WIFE. DEVEL. CACH.		9730 11./3	2/31 7.10
	40	CL				
	SAB?		RIG MUD BOTAEY	GEOPHYS. LOGGING:		
	200	CL	BIT(S) TEI - CONE	CASING:		
	\$ IN	-30FK 50	511,07		8/3/ 9:30	- 1030
	2 %	SD *	DRILLING FLIID MAT. NEVD			
	TCH MAI	CL	·			
	SKEAMENO,	25	SURFACE CASING	FILTER PLACEMENT	2/3/ 10:30	10.50
		CL+SD	WELL DESIGN:	CEMENTING:	<u></u>	
		10	,	DEVELOPMENT:		-
	LOCATION	FN SD	BASIS: GEOLOGIC LOG X GEOPHYSICAL LOG	OTHER:	[{ }	
			CASING STRINGISH C=CASING S=SCREEN			
		[CL	18 - 88 5			
		•				
		TENE				
	1 }	FH SD		WELL DEVELO	DAFAG	
	11	1 (1		WELL DEVELO	PMENI	
	11			·		
	\sim	149				
	AFB	CL	CASING: CI			
	4		C2			
			C3			
	F	1_ 2	SCREEN: SI			
	CLEILAN	FN-HED	S2			
	3		53	COMMENTS:	_	
-	0	SD DE	54	<u> 8/50-11:2</u>	5- MID DUP	ゆ じっぷく
	100	78=	CENTRALIZERS		7.15.12:35 ?	
	7	FH SD			PET 1 50. 7	
	5		FILTER MATERIAL MONERAY "3"		25') CONTROLS	2 2). FINGE
	PROJECT	FNSD	FILTER MATERIAL MATERIAL	4.40 DA11 12	D 70 50' 27' 5	SEMMITTED SO
		Cr	CEMENT		CONTRA 65-85	
		DEY SO			O' WILL COMMET	
		CL	OTHER	W. 18 MW 30		
The state of the s		FN SD				
		EL SD AME	·	9/2 08:45 N.L.	s 80.7-1.1 = T	
		62 13		L <u>'</u> -		
		-190				
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Pro		ct_	M	-	ELLA	MY AF	300	No.			[-]				2 <u>te 8</u>	<u> 7/30/8</u>
Gro	برم	d E	20	/			Hole	No	345	·	Dia	82	5 ,	<u></u> D		
							FIREL	- Hos	= No							
					Drill		,	_		Į,				OTH_		
Was	res	-				v	ed	<i>Dr.</i> 	Non	<u>ا ج</u>				4	a	
		_			-	′		_	Show	-		COULE	2) E /	Find [Core	and
Pro		Den	10	20.44	<u> </u>	FIE	2 هــــ						50.11	Moves	Coser	Care
			\top				CLAY									
Ì		0-2	1	CL		KLD	0041						1		20	İ
 			+			mark.	- COSSE	-	C1 12%		1400		 			
		2-3	' S	C	 	MED	- 00/300	30 7	U. (672	<u> </u>	owie.		4			
			+		 	- P-1	0114	, 	. —				 -			
		3-5	- (CL.	 	KEL	> CLAY	~							ŁD	
	<u> </u>		+			77/	<u> </u>	·					-			
	;	5-53	15	7	 	PN	5D	·					-		ZD	
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		17-20		ZL.		C/K	CL 9 so	me FN:	50]			
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Water Table AT Driving: Water Table AT Driving: Water Depth F Encountered
21-22 CL. HD ZED DRY CUM 21-21 SP FN SD - MICHERY 21-29 CL. OR CHY TRI 21-31 SP FN SD - MICHERY 31-33 SC SD 4 CR CLAY 31-33 SC FN SD 4 CLAY 31-33 SC FN SD 4 CLAY
21-22 CL. HD 20D DRY CUNY 11-27 SP FN SD - MICHORUS 11-29 CL. CR CHN TRI 21-31 SP FN SD MICHORUS 31-33 SC SD 4 CR CLNI 33-35 SC FN SD 4 CLNI
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$
31-29 CC. 29-31 SP FN SD MIGHTS 31-33 SC SD 4 GR OLAY 33-35 SC FN SD 4 CLAP
31-33 SC SD 4 GR OLAN 31-33 SC FN SD 4 CL417
37-33 SC FNSD & CLAP
3550 50
Det CLAY
36-37 CL. RED CL41
37-41 SC OREY CLAY 4 SD 13D: LINSE 395-40) NO SAUDIE 40'
41-44 SM VFN SILTY SD
Serpres - Standard Comments:
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Laboratory Sample Description

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	39-6	2	CL		-1	CC			TN	
	62-6	5	CL	-	28	<i>.</i>		Der	22	
	65-20	, .	<u> </u>	F	N-MED	s⊅.				
	Ø-75	3 <	57		FN	52				
	83.8	9 0	26		(£ CL :				
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	92-10	1 4	5C		7	SD, CL	+			-
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Dept	Sed.	Shelby	Auger	Fland	7001	Laboratory Sample Desc	riptio	2		5
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WELL 35 5 WELL CONSTRUCTION SUMMARY ELEVATION: GROUND LEVEL LOCATION or COORDS: _ TOP OF CASING . DRILLING SUMMARY: CONSTRUCTION TIME LOG: 40.0-START FINISH TASK BOREHOLE DIAMETER __ TIME DATE TIME DRILLING: DRILLER Water Devel GEOPHYS. LOGGING BIT(S) -CASING: - 5 Maduelo (mus DRILLING FLUID _ SURFACE CASING FILTER PLACEMENT CEMENTING: WELL DESIGN: 2.00 ن نوز جد DEVELOPMENT: BASIS: GEOLOGIC LOG & GEOPHYSICAL LOG. OTHER: CASING STRINGIST: C=CASING S=SCREEN WELL DEVELOPMENT Clean fresh who CASING: CI 11.65-65 -COMMENTS: 08.17-76.05-1.65= 166 FILTER MATERIAL __RSO -@ 64.5' CEMENT . 5A

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Grow	nd E	ev_			Hole M	16	<u> 35 S</u>	Die	. <u>B'l</u>	<u></u>	. .	1/5	
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PLOE	Deres	Ciass		FIE	4D So,	12 2	Pasc	<i>マノア</i>	ION	Stiff	Morare	Coser	Care
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	12-19	żw	Fine-	Mak	Eaud -	Hicaco	laus					GR.	
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	52-60	CL	. Be	Clay	, luns	Black	<u>50</u> .					9	32	
	60-69	CL	Re	es cla	my w	Be. Cla	£-7 ;						PD.	
	69-13	SW			e se	-							BL.	
	73-17	CL	Ex	e ch	(eng								ZP	
	17-1/5	CL	Cre	y Clu	y (Eulls) 1-72	- P'	15-10	4 66	¥	,	shif	אק <i>ס</i>	Ĉe.	
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WELL	عات	<u> </u>

<u>.</u> .		WELL CONSTR	ELEVATION: GROUP	ID LEVE		.14	
11		DRILLING SUMMARY:	CONSTRUCTION	TIME		FIN	194
Ø vi		TOTAL DEPTH 47 BOREHOLE DIAMETER 8"	<u>task</u>	DATE	1		
AFR, INV. E	-	DRILLER Water Development Case Woodland CA.	DRILLING:	9117	11:50		13:00
McClellau AFF		Scott RIG Rotary - Dnillech D4CK BIT(S) Wing	GEOPHYS. LOGGING: CASING:	9117	1313C	<u> </u>	<u> </u>
VE!	}	DRILLING FLUID Valual mud					
نے ہے		SURFACE CASING	FILTER PLACEMENT: CEMENTING: DEVELOPMENT:				
LOCATION F		BASIS: GEOLOGIC LOG GEOPHYSICAL LOG CASING STRINGIS: C=CASING S=SCREEN	OTHER:				
_1.1	-0-TS		WELL DEVELOR				
198 1	ML	CASING: CI 4" PVC SCH 40	WELL DEVELOP	MENI			
IRF Phase	SM	cz <u>threaded</u>					
	40 SC	SCREEN: SI 4" Stainless steel, 10states					
(lellau		\$5 \$4	COMMENTS:	·—·—			
되	-60	CENTRALIZERS					
PROJECT	ML 777	FILTER MATERIAL HOWGLEY SOUND # 3 92'-79' CEMENT Grout, 72'- Gr. Level					
•	SM V	OTHER Bentonik seal 79'-72'					
	CL Janes						
	100						

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Well No.: 365

Date: Sept 17, 1982

	17: The 18-18			
Location:	rcclell	lan AFB, CA	Altitude (
Method: R	stary	wash - wing bit	Size of hole:	Size Y V
Driller. W	aler D	evelopment Con	P. WOO	odland, CA
DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
3 -		લા	Fill	•
		rea silt	ML	
15-]	-
20		Reddon by silty sand	CH	fuel smell
30 —				
-		Sandy (fine) silty clay; rd, micauous	SC	fuel smell
45-		clay; rd, micauous		
-			-	· .
		Sandy (fine) +d, bn	ML	still little full smell,
60 —		silt (no mica)		may be residual
75—			•	streaks of white day
_				
		Clean Hockfulnite sand,	SH	
90 —		Green clay	a	
יי		<u> </u>	1 071	

ENGINEERING-SCIENCE

600 BANCROFT WAY, BERKELEY, CALIFORNIA 94710 - 415/848-7970 OFFICES IN PRINCIPAL CITIES

WELL CONSTRUCTION SUMMARY CL + CRACE ELEVATION: GROUND LEVEL 60.04 LOCATION or COORDS: TOP OF CASING _ -10 FK SA DRILLING SUMMARY: CONSTRUCTION TIME LOG: FIN1SH TOTAL DEPTH _ TASK BOREHOLE DIAMETER TIME DATE TIME DRILLING: <u>6:30</u> ، سد SD 207429 GEOPHYS. LOGGING: LUNSES. CASING: 9/13 4.00 DRILLING FLUID NAT. MUD SURFACE CASING. FILTER PLACEMENT CEMENTING: WELL DESIGN: DEVELOPMENT: BASIS: GEOLOGIC LOG ___ GEOPHYSICAL LOG _ OTHER: CASING STRING(S): C=CASING S=SCREEN 5D+ - <u>78 C</u> I MERSED CL SILT WELL DEVELOPMENT PN SD CL4 SET CASING: CI 4" PUC 50 HEL SCREEN: SI Y" JOHNEDY STAINLES 32 10 SLOT. COMMENTS: V.FN.SD. DOT . RETURN TO CONFLETE HOLE 9/13 APRIL REJUILDING FILTER MATERIAL HONTERCY CEMENT. 9 OTHER

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Well No.: 275

Late: 9/8

Location: Mc (Hellan

Altitude (Datum):

60.07

Method: ROTARY

Size of hole: 8/2

Size of casing

Driller: WTR. DEVEZ. CORP.

EPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
)-		2 Red CL & CHAVER	GC	
- ح		PED CC 9 FN SD	CL	
5		7 PREY CI	├	
8-		2 64 65 444		
0 -//-		G FN ST MILACEOUS	SP	
′ -		CREYCL W/SDLEAKES	 	
-		CREY CL @ 13'	l -	
•		FN SD LENSE @ 18 21/31		· · · · · · · · · · · · · · · · · · ·
43		SAMPLE @ 20 (CAPT CL. O CLADO		
22-				
]		·		
30				······································
<i>)</i> '		/ A all a / O as	<u> </u>	·
-		2ED+LACT (1.037-40)		
-		 		
-			l	
40 -			<u> </u>	
43-			-	
,5		CLAY INTERCORD SD.	 	
		\\		
48-		V FN SD, SLICHT MICHEM	 	
3'-		? FINSD, DED SILT		
<u>5</u> 4'-)		•
[ال		INSD U.SUCHI MICH		
. 31				
7		> WHYA SILT	· [

ENGINEERING-SCIENCE

600 BARCROFT WAY, BERKELEY, CALIFORNIA 94710 • 416/649-7970 OFFICES IN PRINCIPAL CITIES

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Well No.: 375

Date: 9/8

Location: Altitude (Datum):

Method: 70TARY Size of hole: 81/2" Size of casing: 4" PUC

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
61 -		7 700 4		
•		3		
44		? SDYSILT.		
, a -		J		
68- 10-		? CL. Der		
r —				
14-				
a/q w1. *		2 VFNSB+ assuran	L	
[4		
% —				
0 ⁻				
23		> FNSD+CL		,
9/8-85		- GEET WAY		9/13- DRILLER FRIED TO
		(MD-5D.		CHETH WL. IN MOLE. ES
90:50				W.L. @ TO'. NOLETAKETA
,,,		 		WHR. ZAPIDLY, DPENTO
-				88' SINIF W.L. DN9
-				25' will complete to
-				BB'. DEILL RIC, TO NOU
				TO 35, STIT CASPING W
_				SMFAL.
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ENGINEERING-SCIENCE

600 BARCROFT WAY, BERKELEY, CALIFORNIA 94710 + 418/548-797 OFFICES IN PRINCIPAL CITIES

WELL _332 WELL CONSTRUCTION SUMMARY ELEVATION: GROUND LEVEL 55.07 LOCATION or COORDS: __ TOP OF CASING DRILLING SUMMARY: CONSTRUCTION TIME LOG: START FINISH TASK DATE TIME DATE TIME DRILLING: DRILLER WIFE DEVEL CORP 10:00 9/15 5:00 GLOY SILTY ZATRLY GEOPHYS. LOGGING: BITIS) BOLLER TO /YS' - WING DID. 1KM (BISUB) CASING: DRILLING FLUID _NAT. MUD 32. SURFACE CASING_ FILTER PLACEMENT LENSES CEMENTING: C2EY WELL DESIGN: DEVELOPMENT: BASIS: GEOLOGIC LOG ___ GEOPHYSICAL LOG_ OTHER: CASING STRING(S): C=CASING S=SCREEN WELL DEVELOPMENT FA SD - 125 TH CL. 18 SUPOL CASING: CI. TH. CL SCREEN: SI Co. SA COMMENTS: BAILER REMOVED FROM 575 240 ROUGH - MUD PIT LEAKING , eL. CENTRALIZERS . BADLY SWITCH TO SHAKETE CREP FILTER MATERIAL MONTOREY "3" CL. CEMENT _

OTHER _

Well No.: 38≥

Location: SAC, CAL, U.CLEICHAL AFB

Altitude (Datum):

Method: ZoTALY

Size of hole:

Size of casing 81/2"

4"

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
2=		3 CLAY	CL_	330-RIL DUEZ HEATED-
- 2 آفی		3 MED-CO. S.D. & GRAVEL	511	DOWN /ZHOUZ.
		LAND FILL - BURNT WOOD	Fill	10:30 - DEILLER FORGOT SAM
یو		GLASS, POLLEUME . ETC.		TUBE - DOWN IHR.
· ·		2 MEDSD-VERY		12:15. MUD PUMP NOT
10-		MILALFOLIS	SW	WORKING AFTER PUNDING
•				WOOD CHIPS.
/5 -		3 co sa & Cener	sw/6M	1:28 - DRILL STEM PULCET
16-		BB. CL. MOIST (AD DEILL)	CL	FROM SAMPLE COLLECTION
18=		3 DEP BE. CL. (EAST DEIL)		RIG DOWN 114R 25 MIN
20		CR. FN SKTY SD	SP	PROTABLY COUSE OF DEL
21 - 23 -		J, 60. SD		100/1001 00000
		2 CR SILTYCL. W/VINSD	CL	
٠, ,		INTERCODED PLASTIC" CL.		
•		VERY SLOW DRILLING		
30-		VEC) SEE DESCURY		
-		COLOR CHANGES TO		· · · · · · · · · · · · · · · · · · ·
-			-	
-		3E@30'		
-				
40-				
-				
45		/		
ב <i>יד</i>		38. CL.		
1		75. 4.		
50-	<u></u>	MUICACEOUS Q 53'	٠	
-				
4		ANALYS - CON BOLL		
-		CHANGES TO GREY @ 54.		
4		BACK TO CONDE GO 60'		
56 			I	

ENGINEERING-SCIENCE 800 BARCROFT WAY, BERKELEY, CALIFORNIA 94710 • 415/548-7870 OFFICES IN PRINCIPAL CITIES

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38 D

Location: JICKALUENTO, CAL. MICCOCK X AFT Attitude (Datum):

Method: EDTARIU

Size of hole: 8/2

Size of casing </"

Driller, WIE DEVEL CORP.

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
-		BR. SUGHTLY	sc	SD IS SO TIME CRAINED STAYS
-		MICHEOLES, 4-V FN SILTY	.	SUSPENDED IN CIRC. WIP.
-		5D9 CL.	4	
-		VERY SLOW DEILLING	_	
10			-	
4			4 1	
-			┧ ┆	
•		- 19' CLAY LENSE	6E>	4:45 - MID PULL THEN
70-		// (34/ 25.136	125	IN you must wood ch
1			1 1	AND PIECES OF RUBBER TH
•		INCHEST CL. CONTENT	.]	DISPOSAL ZONE. COULDAN
]		@ 90'.	1	REGAN PEINE. DOWN INC
/s 90]	IS MIN. END
/3 /0		BETTER CIRC VEICCIT		
		DEILLING RELATIVELY FI	Tel z	
8		BLUE" ELAKE "MINERAL	SH15W	
		(ALTERED MILA)		
صور	_	DOLLING STOWED @ 95'	_	
		RODUS N BP. TLASTIC CL. IN COT	745	
4			-	
•				
116		<u> </u>	+ !	
. 117			1 1	
11' -		G =N SD 1553 CLAPET	5M	
			-	<u></u>
10-		202'	-	

600 BARCROFT WAY, BERKELEY, CALIFORNIA 94710 • 418/648-7970 OFFICES IN PRINCIPAL CITIES

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Well No.: 38).

MICCERCAN AFB Location: SAC. CAL. Altitude (Datum):

Size of casing 4" Size of hole: 8'2 Method: BOTARY

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
		? TAN CL.	CL	
•				
127		<u> </u>		
-	}	3 50.7 CL.		
/30-		 		
/3/ -		> TAN CL. (SLO IN DRILLING)	}	
-	 	7 TAN CC. (SLOW DRICLING	1	CHAKED TO WING BIT @ 148
13.0	1	L HARD DET ER. CI.		ROLLER WAS CLOGGED W/ CLA
- 			1	THAT Z JETS MAY HAVE BEEN
_				PLUCLED AND ROLLERS WOULD
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600 BARCROFT WAY, BERKELEY, CALIFORNIA 94710 - 415/649-7970 OFFICES IN PRINCIPAL CITIES



Well No. 38D

Date: 9/15/82

Location SAC CAL MCCLETCHN ATB

Altitude (Datum):

Method: ROTARY

Size of hole: 81/2

Driller WTE SCIEZ. COEP

EPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
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195			SM	
9		/ MEDSD, SILT.		
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201-			- 	
24) CLIV LETUSE @ 204		
-	 	> FN. SILTY SO.		
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- 'مالايـ				216' - FIG DOWN .UUD P
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ENGINEERING-SCIENCE

900 BARCROFT WAY, BERKELEY, CALIFORNIA 94718 o 418/849-797 OFFICES IN PRINCIPAL CITIES

		1	WELL
		WELL CONSTR	RUCTION SUMMARY
	CIS SD =	DRILLING SUMMARY: TOTAL DEPTH	CONSTRUCTION TIME LOG: START FINISH TASK DATE TIME DATE TIME DRILLING: 9/2 // 170
	-20 Intested 950+44	RIG ROTARY BIT(S) POLLER DRILLING FLIND NAT: MAD SURFACE CASING N/A	GEOPHYS LOGGING:
LOCATION	SD+CL FH-MED SD. -40 CL.	WELL DESIGN: BASIS: GEOLOGIC LOG X GEOPHYSICAL LOG CASING STRINGIS: C=CASING S=SCREEN 1.1 _ 16 72 _ 87	FILTER PLACEMENT CEMENTING: DEVELOPMENT: OTHER:
AFIS	CL. SILTY CL.	CASING: C1 _ Y' DUC	WELL DEVELOPMENT
He Cledur	CLEAN AND-FM SD	CA SCREEN: SI 4" STRINICIS , 10 SLOT S2 76-86' S3 54 CENTRALIZERS	COMMENTS: CONDUCTE FROM TO TO CANTERNE COUNTY VESTORD US TO LONG TO CANTERNE ENGINE LINE INSTEN.
PROJECT	S LPY 5D 77	FILTER MATERIAL LIGHTERY "3"	MN 25 13.32 9/2: 96.2-1.2: 95" W.L. 9:35 9/2: 76.95-71: 95.85 (86.00)

OTHER .

Water Water	:: Dep Was	th M	yeer φ _	: ered	~ -	Waser Tai Waser As Date_ Dry As Cours	Dea W'E	FIND [3 y
Plot		Class	ر تحر	TED SO	Y Pasca	IPTION	Seith Sen	Mose	Cocar
	0-2	CC.		200 004	,				
	2-4	57		MED SI	>				
	4-23	5C	7.S.T	' GR. CL.	INTERSECTION PHR	Inc" By SD.			
	23-25	SC	26	ey Rob CL I	NOTE THE POPULATION OF THE S	D			
	25:31	57		FN SD (CLA)	Y LONSE @ 21.3	ve5)			
	31-35	SC		PHSO DEY	1 800 CL44				
	35-38	5n)		AN-1100 81	b Bluery Pyrin	ič :			
	28.41.	CL.		CRET CL.					
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WELL 405 WELL CONSTRUCTION SUMMARY ELEVATION: GROUND LEVEL 67.76 LOCATION or COORDS: _ TOP OF CASING _ CONSTRUCTION TIME LOG: DRILLING SUMMARY: FINISH START TOTAL DEPTH __ TASK BOREHOLE DIAMETER DATE TIME DATE TIME DRILLING: CORP. Woodland, CA 9/18 10:20 9/18 11:15 RIG Rotary Dilltech GEOPHYS. LOGGING: BITISI WING CASING: 9/18 DRILLING FLUID Dat . WULL 9/18 SURFACE CASING FILTER PLACEMENT CEMENTING: WELL DESIGN: DEVELOPMENT: BASIS: GEOLOGIC LOG X GEOPHYSICAL LOG OTHER: TS CASING STRING(S): C=CASING S=SCREEN 0 - 93 6 HL - 103 5 CL ML WELL DEVELOPMENT 4" PVC SCH 40 threaded SCREEN: 31 4" Staint Steol .40 SW threaded , 10 slots COMMENTS: SM : CENTRALIZERS FILTER MATERIAL MONRULU SOUN #3 CEMENT CITOUT

OTHER Bentonite sea

CL

T.0114'

=S DRILLING LOG

Date: 18 Sept 1982

				18 200, 1100
Location:	uc (lel	lan		(Datum): 67.76 msl
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ENGINEERING-SCIENCE 400 BARCROFT WAY, BERKELEY, CALIFORNIA 94710 • 418/648-7970 OFFICES IN PRINCIPAL CITIES

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Well No.:

405 (continued)

Date:

Location:			Attitude (Datum): 67.76 WSL.
Method:			Size of hole:	Size of casing
Driller.				
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ENGINEERING-SCIENCE

600 BARCROFT WAY, BERKELEY, CALIFORNIA 94718 • 415/548-7970 OFFICES IN PRINCIPAL CITIES

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WELL	4/5			

		WELL CONSTR	RUCTION S	UMN	IARY	3.74	
		LOCATION or COORDS:	TOP O	F CASIN	G F	1./5	
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		TOTAL DEPTH	TASK	1	IIME	-	TIME
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450C	11 1	RIG	GEOPHYS. LOGGING:				
67.77 37.54		8IT(S) ROLER	CASING:	9/5	10:15		
TKH (DISTAND ASSO		DRILLING FLIID NAT MUSS SURFACE CASING NA	FILTER PLACEMENT		_		
		WELL DESIGN:	CEMENTING: DEVELOPMENT:	9/3			
LOCATION		BASIS: GEOLOGIC LOG X GEOPHYSICAL LOG CASING STRINGIS: C=CASING S=SCREEN +1.15 - 100	OTHER:	<u> </u>			
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PROJECT	FN:SD	CEMENT SENTORITE 92-87					
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		5D						<u> </u>	
-	۱			DRILLING SUMMARY:	CONSTRUCTION	_	LOG: ART	FIN	<u>15H</u>
				TOTAL DEPTH 102 BOREHOLE DIAMETER 8/2*	TASK	DATE	TIME	DATE	TIME
		FN SD		DRILLER WATE DOUG. CORP	DRILLING:		10:15	_	11:42
	(12/10)	MD-FIN SD		RIG	GEOPHYS. LOSGING:	_			_
946		ور ا		8IT(S)	CASING:	8/21	11:45		12.40
<u>ن</u>	754			DRILLING PLUID NAT. MUD					
SAC	7	FNSD		SURFACE CASING NA	FILTER PLACEMENT		12:40		100
3	FE	4 CL		WELL DESIGN:	CEMENTING: DEVELOPMENT:				
LOCATION	PERSONNE	43 0 CL		Basis: Geologic Log Geophysical Log Casing Stringisi: C=Casing S=Screen	OTHER:	2/27			
		MDSD		13-93 3 ====					
		FN-UPN							
	1	30		<u>:</u>	WELL DEVELO	MENT	<u> </u>		
		FNSD	1		TRESH	WTP	<u> </u>		
۸.		SDY CL		CASING: CI					
15				cs					
1		SD		α					
147		500		SCREEN: SI					
77	1	er s	┧╵	33	COMMENTS:	rd >	49.7	170	all.
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PROJECT			值	FILTER MATERIAL MONTINEY "3"					
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<u> </u>		17-21	S	G	F	ine Us	LONSOLIDATED SD., OCC. 9R.			CE.	
		21-26	56	J	FN-	Mas	SD. SALT-DEPPER.			-	
·		26-35	CL	-	,	(AZ)	CLA 9'			TN	
		39 -39	51	2	FA	/ SZ	MEA				
		34.pr	CC			CLA	lY			776/	
-		42.45	<u>چ</u>	_		CLAT	SNITERACO FN. SD.				
		45:51	S	W	7	FN-ME	D SALT-PEPPOR SD				
1	ہج	. ده/م. ممری			Stan		Comments:				<u> </u>
Depth	Calle	Sed.	Shelby	Auger	وزودو	700%	Laboratory Sample Descri	ete			57
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rou	nd E	er_			_ Hol	e No.		435	م.	1a.	8	1/2 7	<i>-</i>	102	
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···	CL	WELL CONSTR	FI EVATION: GROU		53.76	ve GL
	76	DRILLING SUMMARY:	CONSTRUCTION	TIME LOG		IISH
	CL	BOREHOLE DIAMETER	TASK		1 -	TIME
100C	-70	DRILLER WITE. DEVA. COR	DRILLING:	8/29 9:	30 ·	11.30
(TOMO? 4	THI SD	RIG	GEOPHYS. LOGGING:			
2017	30 CC	DRILLING FLIND NAT. AUS	CASING:	5/28 (1):3	<u>so</u>	1.00
	Cc+5b	SURFACE CASING NA	FILTER PLACEMENT	e/20 10	<u></u>	1.55
LOCATION	-40 FM 20	WELL DESIGN: BASIS: GEOLOGIC LOG X GEOPHYSICAL LOG	DEVELOPMENT: OTHER:			
LOCA	CL+	CASING STRINGISH C=CASING S=SCREEN - #3 C				
•	9 30	<u>85 - 91 5</u>				
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		CASING: C1 47 PUC				<u> </u>
148	CLAFN SD	C3				
כובונ	FM: 40 51	\$2 <u>\$774\\[67 [.</u> \$3	COMMENTS:			
ACC	20 07	S4	5 BOGS HON PROBABLY TO	81 - D	NEING PO	ACCHET
	B CL 19		LAYER AT	9-74' MAY	YBE SAN	
PROJECT	54 esc	CEMENT 100 165 BOSTONITE ON CRAD DIN	W.L. P/SO			
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12-23 CL 3E. CHY - EASY DELLING 12-23 CL 3E. CHY - WITHESD 12-23 CL 3E. CHY - WITHESD 25-35 CL 3E. HD DEY CLAY DEY CLAY DEY CLAY USD THERSTORY (SAME WITE TAKEN, AND JOINT)	12-23 CL 38 CINY - EASY DENCING 12-23 CL 38 CINY - WITHERD 23-25 FN 3D - (NO SAMPLE MANUE AND SOME) 25-35 CL 38 - AD DEY CINT 3 25-35 CL 38 - CLAY & SD (INTEREDDED) 25-37 SC BE CLAY & SD (INTEREDDED) 25-37 SC DEY CLAY 48-44 CL DEY CLAY 48-54 SC CLAY WISD (INTEREDDED) 25-37 SC SAMPLE COMMENCES: 25-37 SC SAMPLE COMMENCES:
12-23 CL BE CIAY - W TINESD 23.25 SP TN SD - NO SAMPLE 25.25 CL BR - HD DRY CIAI : 25.25 CL BR - HD DRY CIAI : 25.27 SC BR CLAY & SD (INTRESODED) 39.47 SP TN - SD (MICACEDUS) 41.44 CL DRY CLAY 41.44 CL DRY CLAY (SAME WIR TAKEN, AND JOINT) (25.27 NAY W/SD (SAME WIR TAKEN, AND JOINT)	12-23 CL SR CHY - W FINESD 23-25 SP FN SD -(NOT MUN WITH TOWN WHILE NOW SONT) 25-35 CL BR - HD WRY CIAT 25-35 CL BR CLAY & SD (INTRESEDDED) 25-37 SC PR CLAY & SD (INTRESEDDED) 25-37 SC PR CLAY & SD (INTRESEDDED) 25-38 SC PR CLAY & SD (INTRESEDDED) 25-39 SC PR CLAY W/SD (INTRESEDDED) 25-35 CL PR CLAY W/SD (INTRESEDDED) 25-35 CL PR CLAY W/SD (INTRESEDDED) 25-35 CL PR CLAY W/SD (INTRESEDDED) 25-35 CL PR CLAY W/SD (INTRESEDDED) 25-35 CRAY W/SD (INTRESEDDED) 25-35 CL PR CLAY W/SD (INTRESEDDED) 25-35 CL PR CLAY W/SD (INTRESEDDED) 25-35 CL PR CLAY W/SD (INTRESEDDED) 25-35 CL PR CLAY W/SD (INTRESEDDED) 25-35 CL PR CLAY W/SD (INTRESEDDED) 25-35 CL PR CLAY W/SD (INTRESEDDED) 25-35 CL PR CLAY W/SD (INTRESEDDED) 25-35 CL PR CLAY W/SD (INTRESEDDED) 25-35 CL PR CLAY W/SD (INTRESEDDED) 25-35 CL PR CLAY W/SD (INTRESEDDED) 25-35 CL PR CLAY W/SD (INTRESEDDED) 25-35 CL PR CLAY W/SD (INTRESEDDED) 25-35 CL PR CLAY W/SD (INTRESEDDED) 25-35 CL PR CLAY W/SD (INTRESEDDED) 25-35 CL PR CLAY W/SD (INTRESEDDED) 25-35 CL PR CLAY W/SD (INTRESEDDED) 25-35 CL PR CLAY W/SD (INTRESEDDED) 25-35 CL PR CLAY W/SD (INTRESEDDED)
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AT MAY WAD	39-17 SP FN - SD (MICACEDUS) TO THE CL DEY CLAY W/SD (INTERDICIDED) 44-51 SC Game WIZ TAKEN, AND JOINT) SA-57 SC Games - Games Commence:
47.44 CL DRY CLAY DRY CLAY USD (INTERICAND) (SAME WIR TAKEN, AND JOINT) WITH DIAY (WSD)	JAMES - Seendard Commence:
4454 SC PED CLAY W/SD (INTERDEDED) (SAME WIR TAKEN, AIND JOINT) (SAME WIR TAKEN, AIND JOINT)	Serples - Seendard Commence:
(SAME WIE TAKEN, AIND JOINT)	Same with TAKEN, AIRD JOINT) 54-57-50 Seendard Comments:
wer near wish	Samples - Seendard Comments:
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WELL 455

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	SP		DRILLING SUMMARY: TOTAL DEPTH / O Z	CONSTRUCTION TIME LOG: START FINISH
	CL		BOREHOLE DIAMETER 8.5"	TASK DATE TIME DATE TIME
	-20		DRILLER Scott - Water Der	3-24 725-8Z
	cl		ma Drittech NYOK	GEOPHYS LOGGING:
			BIT(S)	CASING: 8-25-82
	10 HL		CLOC WATER MILET	
]]		SURFACE CASING	FILTER PLACEMENT 8-25-27
LOCATION	4	ew	WELL DESIGN:	DEVELOPMENT: 8-25-8
LOCATION	66		BASIS: GEOLOGIC LOG X GEOPHYSICAL LOG CASING STRINGOSE C= CASING S=SCREEN	OTHER:
3 2	SP		2-80	
1	300	<i>77</i>		
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		12may		WELL DEVELOPMENT
	L.,	8		HOSE BING ELECTION
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7		,	SCREEN: SI	
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PROJECT_			FILTER MATERIAL MONTE 184 3	
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			OTHER Bentomit	
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FIRED Engr/Tech FH Sheve of ? Prosect McClerlan Tob No. [Hole No. 455 Ground ELEV. FIREL HOLE NO-Water Table AT Druling: Water Table After DRILLING Water: Depth / Encountered ____ Dry Nort Water At Depth. Waren-After & __ Dry AT DEETH. Caved - After . COULDN'E FIND . COVERED FIELD SOIL DESCRIPTION Sm VS gnond Sin bn The 15 an bu Comments: Laboratory Gampia Description Form 1-102 1-392

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	r: De, Wa	rer-A	Final Pruling: Encountered Ster & cer#	_ DOS Nort Water	A= D=	AFECE DRI OEA BY_ EN Find: [] Cove	
	aces.	Cease	FIELDS	OIL PASCRIPTION			
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	r.	WELL CONSTR				
	PN SIS	LOCATION OF COORDS:	ELEVATION: GROUP TOP O	nd Level F casing	1.5.6	7
11	SD#CL	DRILLING SUMMARY:	CONSTRUCTION	TIME LOG		
	FN SD	TOTAL DEPTH /06 BOREHOLE DIAMETER 8/2"	TASK	DATE IIN	-	TIME
2	-20	DRILLER WHE. DEVEL. COEP.	· DRILLING:	9/1 3.2	5 9/1	<u>4:50</u>
77	FN SL	RIG ROTALY	GEOPHYS. LOGGING:			
ME.SH	-30 _{FN}	BIT(S) ROLLER	CASING:	2/4 30	<u>- or</u>	6%
SACKAMENO	SD SC Sco	DRILLING FLIID NAT. MUD SURFACE CASING NA	FILTER PLACEMENT			
اي ا	20+U.	WELL DESIGN:	CEMENTING: DEVELOPMENT:	9/3		
LOCATION PERSONNEL	30766	BASIS: GEOLOGIC LOG GEOPHYSICAL LOG CASING STRINGIS: C=CASING S=SCREEN 7/ - 87	OTHER:		_	
	AD SD	<u> </u>				
	CL.		WELL DEVELOR	MENT		
	CL.					
250	FN SD	CASING: CI #" PUC				
		C3				
ecch	70 00 5th Ct. 50 ° CL	SZ STANKESS STEEL	COMMENTS:			
Mecce	FN SUT	GENTRALIZERS	<u>SCREEN 87</u> <u>AUL COMPLE</u> 81'=24, 95'=	TED IK S	kty 3ah	D. W.L.
PROJECT &	-80	FILTER MATERIAL MONTERCY "3"	CONTOURS WE PZ'THERE'S	A SAND LA	463a 463a	<u>W. C. o</u> f 97'. Po
<u>8</u>	SILT CL.	CEMENT	HERE.	D IN DICAT	e comp	LETION
	SIITY &	OTHER	W.L. 9:25 \$3 PUMPINE)	: 95-/.3 z	73,7'(86	FORE
フ	5117	97'				

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MAYBE S' OF STUFF ON BOTTOM

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		c-8		,,,	SIFN SD	2300		-		
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<u>-</u>		10-15	SC	14	18D - 7N 5D 4	CLAP				-
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		55°57	sc		TN CLAY I	ntercood 7	154			7.
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WELL 475 WELL CONSTRUCTION SUMMARY CG ELEVATION: GROUND LEVEL 55.29 LOCATION OF COORDS: __ TOP OF CASING . FN. SD. DRILLING SUMMARY: CONSTRUCTION TIME LOG: START FINISH TOTAL DEPTH ____ TASK **PF** 55 BOREHOLE DIAMETER _ DATE | TIME DATE TIME DRILLING: DRILLER WIR. DEVEL CORP. 20 CL. BOTARY GEOPHYS. LOGGING: POLLER CASING: 11:45 1:00 NAT. MUN DRILLING FLUID ... FAL SD. FILTER PLACEMENT SURFACE CASING. FILL S.D. CEMENTING: WELL DESIGN: . DEVELOPMENT: 40 CL 432 BASIS: GEOLOGIC LOG ___ GEOPHYSICAL LOG _ OTHER: CL. CASING STRINGSI: C=CASING S=SCREEN SDT SILT FN SO. WELL DEVELOPMENT CASING: CI 4" POR cc. SCREEN: SI 4" JOHNSON STAINESS - 10 -32 10 SCOT COMMENTS: FK-IFN 53 _ HERE PLACONG LAST SHOW BAG **54** . IN HORE CAUCH IN TO CH! CENTRALIZERS FASD - CL PM- MED 5 D. FILTER MATERIAL MONTESEP"5" CL. CEMENT _ 90 CC+ FN. SD. OTHER . CL.

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Well No.: 475

Date: 9/8

Location

Altitude (Datum):

Method: 20174-27

Size of hole: 83-

る Size of casing

4" PUC

Driller: WTL DEVEL CORT

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
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ENGINEERING-SCIENCE

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Well No.: 475

Date: 9/8

Location: Attitude (Datum):

Method: 20Ther Size of hole: 81/2 of casing: 4" PUC

Domer: WHE. DEVEZ. CORP.

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ENGINEERING-SCIENCE

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WELL 485 WELL CONSTRUCTION SUMMARY CL ELEVATION: GROUND LEVEL 54.23 LOCATION or COORDS: _ TOP OF CASING _ DRILLING SUMMARY: CONSTRUCTION TIME LOG: START **FINISH** ٧. TASK DATE TIME FN SD + BOREHOLE DIAMETER __ DATE TIME DRILLING: DRILLER WHD. DEVER COEP. 12 20 10.00 CL. POTALY GEOPHYS. LOGGING: FH-MED SD BIT(S) CASING: 1:45 NAT. MUD DRILLING FLISTO SURFACE CASING. FILTER PLACEMENT FN. 50. CEMENTING: WELL DESIGN: DEVELOPMENT: BASIS: GEOLOGIC LOG ___ GEOPHYSICAL LOG . OTHER: CASING STRING(S): C=CASING S=SCREEN CL. - 60 C - 70 WELL DEVELOPMENT 50 CASING: CI FN 4" STAINLESS JOHNSON 10 SCREEN: SI SLOT COMMENTS: 10.00 = 10.15-5-69.65 el. SIL FILTER MATERIAL MONTENTY '3" CEMENT . 90 CL.56 OTHER PING

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-	10-11	CL	CLAH			
	11-13	SP	CLEAN FN, SD			
	13-15	CL	Dèr CL			
	15-20	SC	an SD a CL Interdedict			
	20.26	CL	CREY CAY, SOW DRILL			
	26.58	SW	MED-FN SD, CLEAN			
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WELL	495	
SHIMM	ARY	

WELL CONSTRUCTION SUMMARY LOCATION or COORDS: _ ELEVATION: GROUND LEVEL -TOP OF CASING _ DRILLING SUMMARY: CONSTRUCTION TIME LOG: START FINISH. TOTAL DEPTH ____ TASK BOREHOLE DIAMETER _ 8 1/2" DATE TIME DATE TIME DRILLING: DRILLER WITE. DEVEL COZP 0:50 YXX (181516) RIG _ ROTALY LOCATION SACRAMENTO, GEOPHYS. LOGGING: BITIS) ROLLER TO 10', WINK T.D. CASING: NAT. UUD DRILLING FLUID SURFACE CASING FILTER PLACEMENT CEMENTING: WELL DESIGN: DEVELOPMENT: BASIS: GEOLOGIC LOG ___ GEOPHYSICAL LOG OTHER: 32+6269 CASING STRINGIST: C=CASING S=SCREEN - 110 C FN SD CZEY WELL DEVELOPMENT CL. CASING: CI 47 7VC FN-M SD SR. CL. CEEY SCREEN: SI 4" STAINLESS 10 SLOT. COMMENTS: CENTRALIZERS . B. CL. PROJECT FILTER MATERIAL MONTEREY "3" 10.10 CEMENT _ 150 OTHER _

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Well No.: 495

Date: 9/16/82

Location McCLELLAH AFB

Altitude (Datum):

Y STATOS DONOM

Size of hole: 8 2

Size of casing: "

Driller: W.R. DELEL CORP.

PTH TIM	E DESCRIPTION	GRAPHIC LOG	COMMENTS
2 3	BOAD FILL	FILL	
7	RED FELCL.	cl	
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ENGINEERING-SCIENCE

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1-406

200



Well No.:

Location Machiner 173

Altitude (Datum):

ESTILLY

Size of hole: 8 /2

Size of casing.

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
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Location McCLETLAN AFB

Altitude (Datum):

Size

POTSRY

Size 71/2

DEPTH	TIME	DESCRIPTION	GRAPHIC LOG	COMMENTS
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WELL 505

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		LOCATION OF COORDS:	ELEVATION: GROUP TOP O	nd Level F Casin		<i></i>	·	•
	- 1	DRILLING SUMMARY:	CONSTRUCTION					
		TOTAL DEPTH 84.5	TASK	. 3 T	t		IISH I	
		BOREHOLE DIAMETER 8.51	DRILLING:	DATE	1	DATE		
	-	ORILLER Water Dev Corp - Scott & Scott			<u>8-</u>	23 4	<u>24-8</u>	Z
		AIG Dril Fech DYO	GEOPHYS. LOGGING:					
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が 別	+	DRILLING FLUID MUC			<u> </u>			
		SURFACE CASING	FILTER PLACEMENT		5-	24		
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APPENDIX F

SAMPLING EVENTS
BASE PRODUCTION WELLS

SAMPLING EVENTS FOR BASE PRODUCTION WELLS McClellan AFB, California

se Supply Well	Date	Sampling Procedure	Sample
1	12/21/81	Pump ran for 10 minutes. Water was initially very silty.	2 VOA bottles
	1/11/82	Pump ran for 10 minutes.	1 gallon bottle (GC/MS) 2 VOA bottles 1 gallon bottle (pest/herb/metals
2	12/21/81	Pump ran for 10 minutes. Water was initially silty.	2 VOA bottles
	1/11/82	Pump ran for 10 minutes.	1 gallon bottle (GC/MS) 2 VOA bottles 1 gallon bottle (pest/herb/metals
8	12/21/81	Water ran for 10 minutes. Well on-line.	2 VOA bottles
	1/11/82	Pump ran for 10 minutes.	1 gallon bottle (GC/MS) 2 VOA bottles 1 gallon bottle (pest/herb/metals
11	12/21/81	Pump ran for 10 minutes.	2 VOA bottles
	1/11/82	Pump ran for 10 minutes.	1 gallon bottle (GC/MS) 2 VOA bottles 1 gallon bottle (pest/herb/metals
12	12/21/81	Pump ran for 10 minutes. Water was very silty.	2 VOA bottles
	1/11/82	Pump ran for 10 minutes.	1 gallon bottle (GC/MS) 2 VOA bottles 1 gallon bottle (pest/herb/metals

SAMPLING EVENTS FOR BASE PRODUCTION WELLS (Continued)

se Supply Well	Date	Sampling Procedure	Sample
13	12/21/81	Water ran for 10 minutes. Well on-line.	2 VOA bottles
-	1/11/82	Water ran for 10 minutes. Well on-line.	1 gallon bottle (GC/MS)
			2 VOA bottles
			1 gallon bottle
			(pest/herb/metals
17	12/21/81	Water ran for 10 minutes. Well on-line.	2 VOA bottles
	1/11/82	Water ran for 10 minutes. Well on-line.	1 gallon bottle (GC/MS)
		•	2 VOA bottles
			1 gallon bottle
			(pest/herb/metals)
18	12/21/81	Pump ran for 10 minutes.	2 VOA bottles
	1/11/82	Pump ran for 10 minutes.	1 gallon bottle (GC/MS)
			2 VOA bottles
			1 gallon bottle
			(pest/herb/metals)
28	12/21/81	Pump ran for 10 minutes.	2 VOA bottles
	1/11/82	Pump ran for 10 minutes.	1 gallon bottle (GC/MS)
			2 VOA bottles
			1 gallon bottle
			(pest/herb/metals)
29	12/21/81	Water ran for 10 minutes. Well on-line	2 VOA bottles
	1/11/82	Pump ran for 10 minutes.	1 gallon bottle (GC/MS)
			2 VOA bottles
			1 gallon bottle
			(pest/herb/metals)

APPENDIX G

SAMPLING EVENTS BASE MONITORING WELLS

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SAMPLING EVENTS
FOR BASE MONITORING WELLS
MCCLELLAN AFB, CALIFORNIA

Monitoring Well	Date	Water Level (feet)	Sampling Procedure	Sample
e	12/21/81	(Closed well cap with pump in- stalled in well)	Generator was connected to in-place pump, water flowed immediately at high rate. Two samples were taken after 10 minutes.	2 VOA bottles
•	12/21/81	· · · · · · · · · · · · · · · · · · ·	Generator was connected to submerged, in-place pumps with extension cord. After 10 minutes of pumping, no water appeared. Well was probably dry, possibly due to new base supply well (BW29) adjacent to MW4.	None 1
	1/11/82	101	In-place pump had been removed. One sample was taken with bailer after 1-1/2 gallons of well water were removed.	1 VOA bottle
	3/31/82	100	Bailed 1-1/2 gallons of well water and used bailer for sampling.	i gallon bottle (GC/MS) 2 one-liter bottles (pest/herb/metals) i VOM bottle
9	12/22/81	06	The pump was too big for the well casing. The 250-ml bailer was used to bail ten times its volume of water before sampling.	1 VOA bottle 1 rinsewater sample
	3/31/82	88	Bailed 1-1/2 gallons of well water. Sampled with bailer.	<pre>1 gallon bottle (GC/NS) 2 one-liter bottles (pest/herb/metals) 1 VOA bottle</pre>

SAMPLING EVENTS FOR BASE MONITORING WELLS (Continued)

Monitoring Well	Date	Water Level (feet)	Sampling Procedure	Sample
,	12/22/81	\$6	The 250-ml bailer was used to bail ten times its volume of water before sampling.	i VOA bottle i rinsewater sample
	3/29/82	98.5	Pumped for 40 minutes. Sampled with bailer.	<pre>1 gallon bottle (GC/MS) 2 one-liter bottles (pest/herb/metals) 1 VOA bottle</pre>
80	12/22/81	100	Bailed 2 gallons of well water. Bailer defective. Almost no water in well.	None
	3/31/82	66	Bailed 1-1/2 gallons of well water prior to sampling with bailer. Very little water in well (approximately 2 feet).	<pre>1 gallon bottle (GC/MS) 2 one-liter bottles (pest/herb/metals)</pre>
6	12/22/81	95	Bailed 1-1/2 gallons prior to sampling. 1 VOA bottle Sampled with the bailer.	. 1 VOA bottle
	3/31/82	7.7	The well cap was missing. Rainwater had entered the well. Well sampled with bailer.	<pre>1 gallon bottle (GC/MS) 2 one-liter bottles (pest/herb/metals) 1 vOA bottle</pre>
	4/28/82	93.3	Pump ran for 20 minutes. Samples were taken from Teflon tubing.	<pre>1 gallon bottle (GC/MS) 1 gallon bottle (pest/herb/metals) 1 VOA bottle</pre>

1-4/6

G-2

SAMPLING EVENTS FOR BASE MONITORING WELLS (Continued)

Monitoring Well	Date	Water Level (feet)	Sampling Procedure	Sample
0	12/22/81	61	Bailed 1 gallon of well water. Sample taken with bailer.	1 VOA bottle 1 rinsewater sample
	1/11/82	79	Mil0 was resampled for TCE.	1 VOA bottle
	3/30/62	78.5	Bailed 1-1/2 gallons of well water prior to sampling. Sampled with bailer.	1 gallon bottle (GC/MS) 2 one-liter bottles (pest/herb/metals) 1 VOA bottle
=	12/22/81	18	Bailed 1 gallon of well water. Sampled with bailer.	1 WOA bottle 1 rinsewater sample
	3/30/82	76.2	Bailed 1-1/2 gallons of well water. Sampled with bailer.	<pre>1 gallon bottle (GC/MS) 2 one-liter bottles (pest/herb/metals) 1 VOA bottle</pre>
	8/18/82	78	Pump ran continuously for 27 minutes at >2.5 gpm. Sampled with pump. Three casing volumes were removed prior to sampling.	1 gallon bottle (GC/MS) 2 VOA bottles

G-3

SAMPLING EVENTS FOR BASE MONITORING WELLS (Continued)

Monitoring Well	Date	Water Level (feet)	Sampling Procedure	Sample
13	12/22/82	83	The 250-ml bailer was used to bail ten times its volume of water.	1 VOA bottle 1 rinsewater sample
	4/29/82	82	Pump ran for 30 minutes. Samples were taken from Teflon tubing.	1 gallon bottle (GC/MS) 1 gallon bottle (pest/herb/metals) 1 VOA bottle
	8/18/82	84.1	Continuous pumping for 20 minutes at >2.2 gpm. Sampled with pump. Three casing volumes were removed before sampling.	1 gallon bottle (GC/MS) 2 VOA bottles
13	12/22/81	92	Bailed 1-1/2 gallons of well water. Sampled with bailer.	1 VOA bottle 1 rinsewater sample
	3/30/82	18	Bailed 1 gallon of well water. Sampled with bailer.	1 gallon bottle (GC/NS) 2 one-liter bottles (pest/herb/metals) 1 VOA bottle
	8/18/82	82.6	Continuous pumping for 20 minute sat >2.2 gpm. Sampled with pump. Three casing volumes were removed before sampling.	1 gallon bottle (GC/MS) 2 VOA bottles

G-4

SAMPLING EVENTS FOR BASE MONITORING WELLS (Continued)

Monitoring Well	Date	Water Level (feet)	Sampling Procedure	Sample
-	12/22/81	58	Bailed 1-1/2 gallons of well water. Sampled with bailer.	1 VOA bottle 1 rinsewater sample
	3/30/82	81.5	Bailed 1-1/2 gallons of well water. Sampled with bailer.	1 gallon bottle (GC/MS) 2 one-liter bottles (pest/herb/metals) 1 VOA bottle
	8/18/82	82.6	Well was pumped continuously for 20 minutes at >2.2 gpm. Sampled with pump. Three casing volumes were removed prior to sampling.	<pre>1 gallon bottle (GC/MS) 2 VOA bottles 1 quart polyethylene bottle (cyanide)</pre>
15	12/22/81	82.5	Bailed 1-1/2 gallons of well water. Sampled with bailer.	1 VOA bottle 1 rinsewater sample
	4/29/82	Excessive silt	Very little water in the well. Samples taken with plastic bailer.	<pre>1 gallon bottle (GC/MS) 1 gallon bottle (pest/herb/metals) 1 VOA bottle</pre>
	8/18/82	18	Well pumped dry after 10 minutes of pumping at 2.5 gpm. One casing volume was removed before sampling. Samples were collected using double sampler technique. Water level was 99 feet prior to sampling.	<pre>1 gallon bottle (GC/MS) 2 VOA bottles</pre>



DEPARTMENT OF THE AIR FORCE HEADQUARTERS AIR FORCE LOGISTICS COMMAND WRIGHT-PATTERSON AIR FORCE BASE OHIO 45433

NEPLY TO

26 October 1983

SUBJECT

Final Report, Phase II Installation Restoration Program, McClellan AFB, CA

AD-A13/364

See Distribution List

The attached errata sheets for the subject report are forwarded for your information and action. Please forward copies of the errata sheets to all recipients of the subject report.

FOR THE COMMANDER

HARRY C. RUSSELL, Colonel, USAF, BSC Command Bioenvironmental Engineer Office of the Surgeon

1 Atch Errata Sheets

McClellan AFB Installation Restoration Program Phase II Final Report

Errata

Page	Paragraph/Line	Change
B- 6	First full/7	Change sentence to read, "Chemical constituents have been detected in downgradient areas off the base."
2-4	Fig. 2.2/Reference	Reference should read "DWR, 1974".
2-26	Fig. 2.8	Base well 29 was mistakenly left out of Figure 2.8. The location of the well can be found on Figure 8.2, page E-8.
4-43	Second full/7	Add sentence to end of paragraph, "Monitoring well 27S contained 15 ppb of TCE and 120 ppb of pentachlorophenol."
4-43	Last/10-12	Delete entire sentence.
4-45	3/1-5	Delete entire paragraph as written. Change to read, "Monitoring well 37S was installed to determine if contamination was migrating from site 33. However, the groundwater gradient in the area of MW 37S is flat (see Figure 4.7, page 4-60), and MW 37S cannot be assumed to be downgradient of site 33."
4-49	Last/5-7	Delete sentence, "The analytical results below established standards."
4-58	1/11-14	Change sentence to read, "The recharge area for the shallow water-bearing sands appears to be from two to ten miles upslope (east) of the base."
4-59	1/9	Change to read "would be less than one foot per year"
4-71	Top/1	Change to read "trough exists north of the City of Sacramento"

5-1	Last/3	Change to read "disposal at Class I or Class II-1 site will be necessary."
5-7	Last/3	Change to read "treatment will be necessary."
5-30	2/4-5	Change to read "The aquifer is flowing at a gradient approximating 0.07 percent."

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